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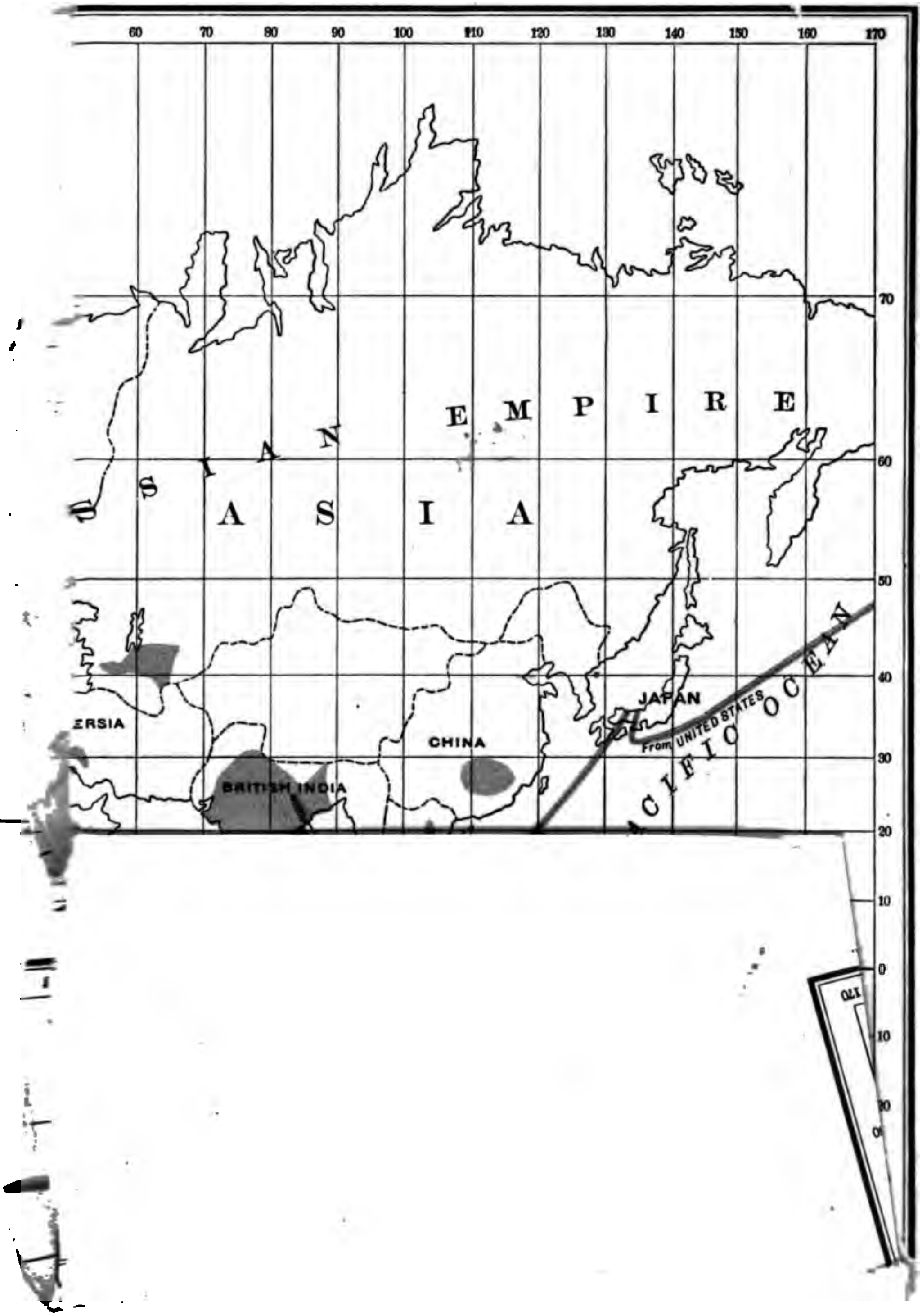
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COTTONSEED PRODUCTS

A MANUAL OF THE TREATMENT OF COTTONSEED FOR ITS PRODUCTS AND THEIR UTILIZATION IN THE ARTS

BY

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PREFACE.

THE purpose of this book is to supply a demand for a treatise on the subject of cottonseed which should deal not only with the extraction of the oil from the seed, but with the utilization of the products of the seed as well. With this purpose in view, this book is submitted to a clientele which includes the technical student, the practical man in the fat and oil industries, the cottonseed-oil miller and, last but in nowise least, the consumer of the products of cottonseed.

The rise of the cottonseed industry during the past two decades has been a phenomenon among phenomena that have made the United States the *premier* industrial nation of the world. It has dotted the South from the Roanoke to the Rio Grande with 618* separate mills utilizing in an intricate and costly manufacturing process what forty years ago was a nuisance that required for its control the enactment of legislation. The economic significance of this injection of industrial blood into the anæmic veins of a body laid prostrate by a great internecine struggle, does not escape the student of social conditions.

Our interest in this book, however, is confined to the products obtained from the seed of the cotton-plant; how they are made into saleable goods of great value, and how these in turn are used in the production of other goods essential to human sustenance and comfort. These products, like all others that rise to compete with similar ones already in use, have run the gauntlet of suspicion, recognition, and adoption. They have been compelled to mas-

* A canvass by mail of the cottonseed-oil industry reveals the fact that 644 cottonseed-oil mills reginned seed of the growth of 1903. Bull. 10. Bureau of Census.

querade, and to fight for recognition; and recognition having been obtained, the industry has been subjected to restrictions through legislation to limit the use of a product based on merit and native value.

In the preparation of this book, tribute has been levied upon reports of the XII. Census and upon numerous publications of the Divisions of the Department of Agriculture. Analytical data have been used exclusively from these sources and to that degree are authentic and reliable. The Report of the Commissioner of Agriculture of North Carolina for 1903 has contributed matter relating to the feeding and fertilizing value of cottonseed and their products. For illustrations of machinery, credit is due to the Cardwell Machine Company of Richmond, Va., to the Planters' Compress Company of Boston, Mass., to the E. Van Winkle Gin and Machine Works of Atlanta, Ga., to the Continental Gin Company of Birmingham, Ala., to the Stillwell-Bierce and Smith-Vaile Company of Dayton, Ohio, to the Foos Manufacturing Company of Springfield, Ohio, to the French Oil Mill Machinery Company of Piqua, Ohio, to the Hersey Manufacturing Company of Boston, Mass., to the Lobee Pump Co., Buffalo, N. Y., and to Houchin and Huber, Brooklyn, N. Y.

L. L. L.

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CHAPTER I.

THE COTTON-PLANT.

The Plant. Geographical Distribution. Area of Cultivation in the United States. The Fibre. Ginning. Baling. The Seed.

To the technical student of cottonseed products, and especially to those who are chiefly concerned with their practical utilization, interest in the plant that bears the seed involves application to a remote province of work. Likewise the art for which the plant is primarily cultivated is, in its intricacy, extent, and numerous branches, equally remote. Our present interest in the cotton-plant is confined to its function of bearing an oil-producing seed and in nowise includes the utilization of the fibre with which the seed is covered. Wherever the plant is cultivated seed is produced, and from the seed may be expressed a valuable oil. Our interest in the subject of its geographical distribution and area of cultivation is chiefly from the standpoint of present and prospective supplies of seed and oil.

The Plant.—The cotton-plant in a state of nature is a perennial shrub growing to a height of 6 to 8 feet, but in cultivation it is an annual or biennial 3 to 4 feet high, with main stem erect, with smooth, graceful, slender, spreading branches bearing three- to five-lobed leaves. On planting the seed is drilled in rows about four feet apart, and as the seed sprouts, the plants are thinned out to about a foot apart. The earliest planting occurs in southern Texas March 1; the

first blooms appear May 15; the first bolls open June 15; picking commences July 10. Corresponding time elapses in the same intervals of the development of the plant in other sections of the cotton belt. Thus, in northern Georgia seed is planted April 10; first blooms appear June 20; first bolls open July 20; picking commences August 20. The picking season averages 100 days in duration.

FIG. 1.—Upland Cotton-plant.

An ordinary hand will pick at least 100 pounds of cotton per day. The cotton-plant is much subject to the depredations of insects, chiefly the cotton-worm, boll-worm, and Mexican cotton-boll weevil, which inflict enormous loss, as well as to diseases due to physiological causes, fungi, and worms.

Geographical Distribution.—Cotton in its several species and many varieties is a product which belongs to all tropical countries, for the plant has been so widely distributed and has been in cultivation so long a time that in many of these countries it is considered

indigenous. Spon gives the geographical parallels between which cotton is usually cultivated as stretching in varying girdles between 36° north latitude and 36° south latitude, though Evans * places the parallels at 40° or more on either side of the equator, or to the isothermal line of 60° Fahr. In the United States 37° north latitude about represents the limits of economic growth. On the accompanying map are shown the regions of cultivation of present economic importance. (See frontispiece.)

The Fibre.—The lint, or fibre, of cotton is the seed-hairs which are found in the point, or boll, of the plant after maturity. The

FIG. 2.—Cotton on the Seed.

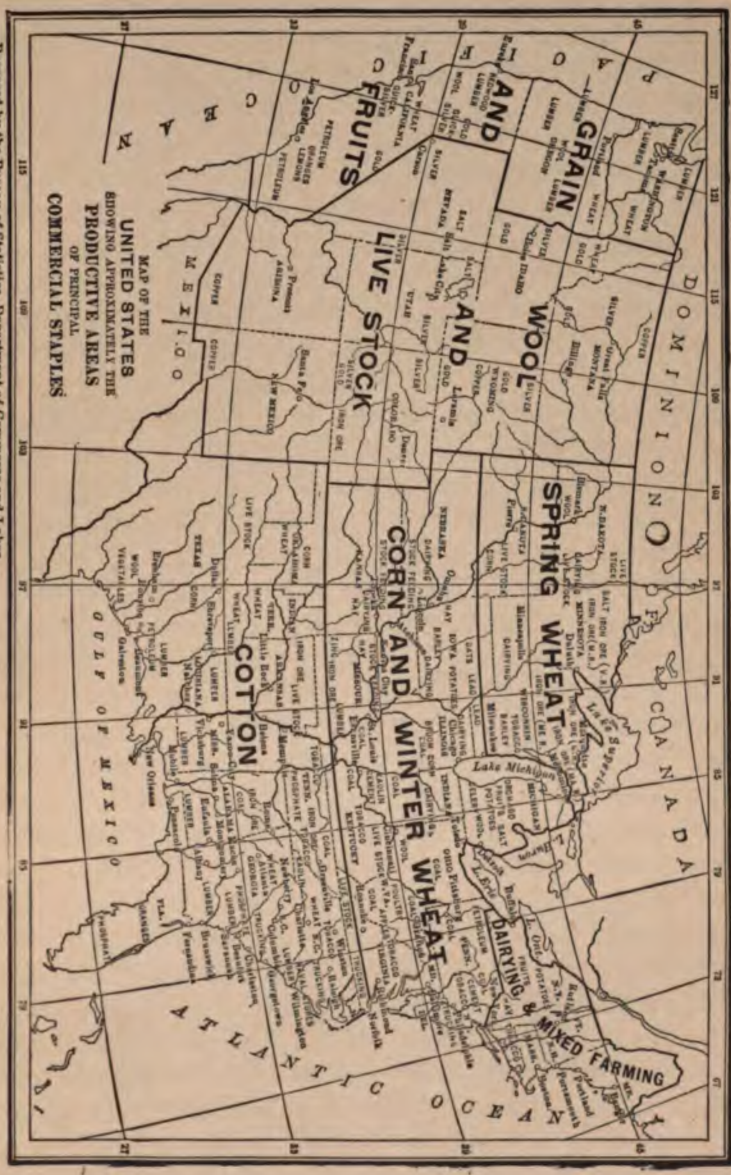
value of the lint depends upon the length of these seed-hairs, and this is known as the "staple." Naturally the "short staples" are of less value than the "long staples." Upland cotton, which forms the greater part of that grown in the United States, is an example of the former; sea-island cotton, of the latter. Seen longitudinally the fibres of cotton appear quite independent of each other; they are flat and more or less twisted, like a corkscrew. Long staple varies from 1 to 1½ inches in length; short staple, ⅝ to ¾ inch. Fig. 2 shows the staple carefully smoothed out to show the seed; naturally the fibre is in a conglomerate mass about the seed.

* Bull. 33, U. S. Dept. of Agr.

Area of Cultivation in the United States.—In the United States the upland-cotton belt extends from southeast Virginia to Texas and its distribution is mainly between the tide-water district and the foot-hills of the Appalachian mountain system. The deep alluvial soils of the Mississippi Valley favor extension of cotton-growing much farther northward, from the sugar district of southern Louisiana to the southern border of Missouri, including most of Arkansas and western Tennessee, while the higher elevation of central and eastern Tennessee limits culture and diverts sharply the line of limitation around the foot-hills of northwestern Georgia. Fifty years ago Mississippi, near the then western border of cultivation, had surpassed other States and produced nearly one-fourth the product; now Texas, on the extreme west, yields one-third of the crop doubled in volume. Except a very limited area in Virginia, Kentucky, Missouri, and Oklahoma, cultivation is mainly confined to suitable and comparatively limited districts in North and South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Arkansas, Louisiana, and Texas.

Ginning.—Prior to the invention of the cotton-gin by Eli Whitney in 1794 the separation of the seed from the lint cotton was so difficult as to limit the cultivation of cotton. This separation of the seed from the lint had to be done by hand, a task being 4 pounds of lint cotton per week for each head of the family, working at night in addition to the usual field-work. Thus it would take one person two years to turn out the quantity of cotton contained in one average standard bale. One machine will gin from three to fifteen 500-pound bales per day, dependent upon its power and saw capacity. While several machines had been invented for the seeding of cotton, it was reserved for Eli Whitney to inaugurate, by his invention, the era which was to perfect the industry of "cotton-ginning" and revolutionize the culture and commerce of the staple.

The primitive saw-gin was operated by hand and was of necessity exceedingly limited in capacity. The first very substantial advancement, resulting from years of research, was the horse-power attachment for ginning and baling, which brought the old-fashioned cotton-ginnery and screw. The motive power for this ginnery consisted of two, four, or more horses or mules. The cotton was hauled in wagons



Prepared by the Bureau of Statistics, Department of Commerce and Labor.

FIG. 3.—From Semple's "American History and its Geographic Conditions." By permission of Houghton, Mifflin & Co.

to the gin-house, unloaded by hand into bins, carried again by hand to a platform, and thence fed by hand into the gin. By the old-fashioned ginnery and screw the lint cotton was blown by a brush from the saw-gin into a lint-room, where it was often allowed to accumulate, awaiting a rainy day or other opportune occasion for baling. It was then conveyed in baskets or sheets to the single press-box of the old "wooden screw," which was located some 30 or 40 feet from the gin-house. There it was dumped into the box and trampled by foot until a sufficient quantity was inclosed to make a bale. By means of a horse at the lever or wing of the press the follow-block, upon which the screw was pivoted, was forced down or up, as the case might be, until the desired bale density was attained. Jute bagging was generally used as a wrapping, and the shape of the bale was preserved, at first by the use of rope, and later by means of iron bands, called "ties."

A few of these "landmarks" are yet found throughout the cotton belt, though they are now curiosities. It is scarcely necessary to say that this old method of handling cotton at the gin was exceedingly laborious, wasteful, and unhealthy, and that nothing but cheap labor and high prices for the staple allowed it to continue as long as it did.

Much time, labor, and money have been expended in efforts to combine ginning and baling plants, to the end that greater speed might be gained, labor economized, and other desired reforms attained in handling seed cotton. The outcome is automatic ginneries, practically doing away with labor, and yielding from five to ten times as much lint cotton per day as was possible by the earlier processes.

Fig. 4 shows a section of a modern cotton-gin through the saw *D*, mounted on the saw cylinder *C*. *E* indicates the grating through which the teeth of the saws project $\frac{1}{2}$ to $\frac{3}{4}$ of an inch and grasp the seed cotton fed into the seed-box *A*. The saws, shown in perspective in Fig. 5, make about 250 revolutions per minute and impart a rolling motion to the mass of seed in the box *A*, from which the fibre is cut by the saws and from them removed by a brush, shown in perspective in Fig. 6, and mounted on the shaft *J* The feed of seed cotton is directed to the outside of the mass of

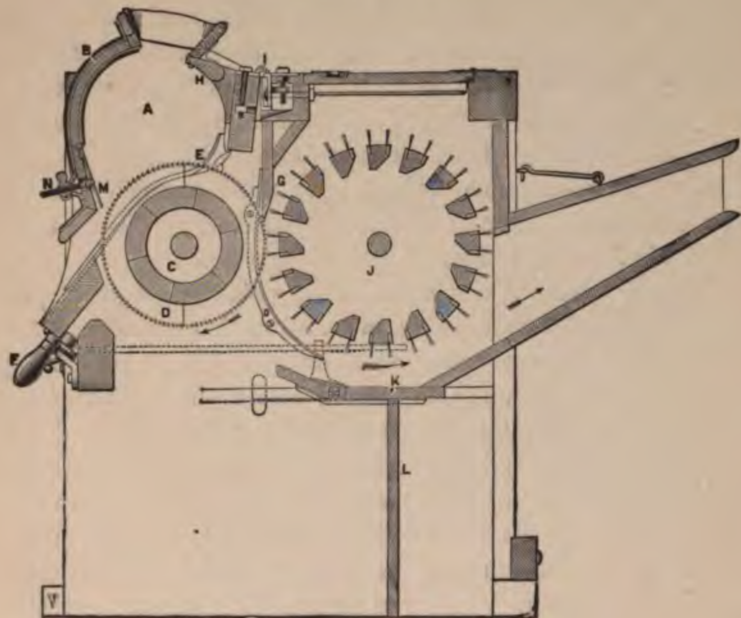


FIG. 4.—Cross-section of Gin.


FIG. 2.—Saw Cylinder.


FIG. 3.—Brush.

seed lying against the saws. Cleaning of the seed is regulated by the movable iron plate *M*, adjusted by the screw *N*. The brush revolves very rapidly (1200 to 1500 revolutions per minute) and throws the cotton with aid of air-current into the condenser in the rear. (See Fig. 19.) The condenser consists of a revolving cylinder of wire cloth upon which the lint is collected and delivered in the form of a sheet. The seed when satisfactorily delinted are discharged in front and deflected into storage-bins.

A modern ginnery, shown in Fig. 7, containing four gins of 70 saws each with a double square-bale press and suction apparatus attached requires an 80-horse-power engine. Such a plant in constant operation will yield from 40 to 60 bales of cotton per day. The wagon, loaded with seed cotton, is driven under a flexible slip of a joint pipe, and the cotton is drawn up by the suction created by an exhaust-fan which is connected with the rear of the vacuum separator and cleaner. By this separator and cleaner the dust, sand, and leaf trash are sifted and drawn through by suction, and thus freed from impurities the cotton is conveyed through a distributer to the automatic gin-feeders. After filling all of the feeders the surplus cotton falls out at the end of the automatic tube and drops upon the floor or into a bin. When the cotton is all out of the wagon or bin, as the case may be, the ginner, by means of a simple lever, causes the suction to change from the direction of the wagon to that of the overflow, and the overflow cotton is conveyed to the gin-feeders. From all the gins the cotton is conducted by a flue system to a condenser, and fed into one box of the self-packing revolving double press. In this way lint is ginned into one box while the bale is being pressed out of the other. Thus the cotton need not be touched by hand from the time it leaves the wagon or bin until it is delivered, a perfect bale, upon the platform where it is loaded ready for market.

Thus from the "hand seeder," yielding about 4 pounds of lint cotton per week, advance has been made to the saw-gin, which, with a 40-saw capacity and horse-power, yielded about 2000 pounds per day, and finally to the complete battery ginnery, carrying in some instances as many as fifteen 70-saw gins, operated by steam and having a possible capacity of 150 bales, or 75,000 pounds, in twelve hours. The condenser and automatic press feed have super-

seded the old "wooden screw." The laborious handling of the seed is avoided, it being blown either into a distant seed-room or into the waiting wagon of the owner. In this way the life and value of the seed are preserved in conformity with the requirements of the oil-mill. Thus the arduous labor heretofore attached to the cotton-ginnery has been wonderfully reduced, and life, limb, and property marvellously protected.

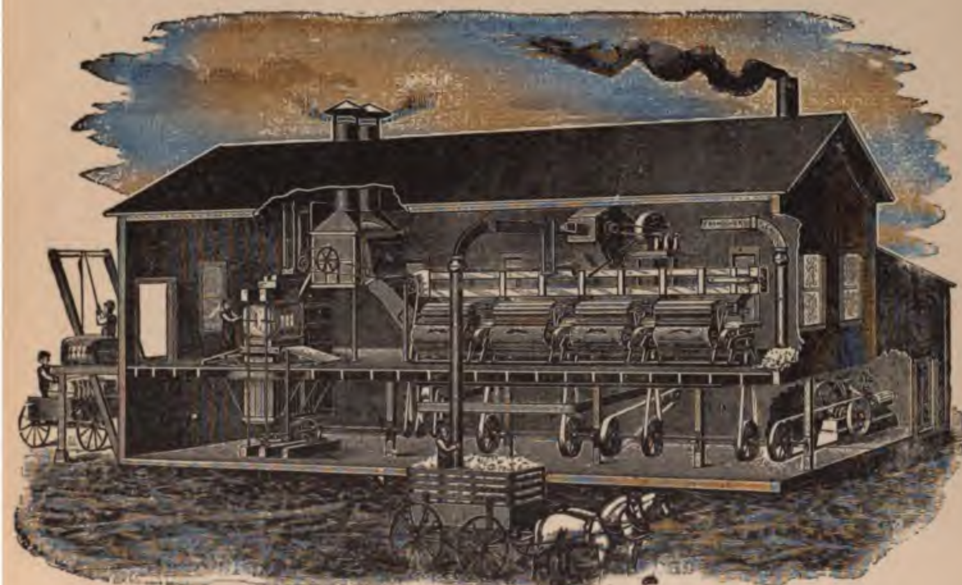


FIG. 7.—Modern Cotton-ginnery—Square Bale.

Possibly no invention ever caused so rapid a development of the industry with which it was associated as that brought through the saw cotton-gin. In 1793 the exportation of cotton from the United States was 487,500 pounds, or 975 bales of an average weight of 500 pounds. In 1794, the year in which the Whitney gin was patented, the number of pounds of cotton exported from the United States was 1,600,000, equivalent to 3200 bales of a 500-pound standard. This large production so frightened the cotton-farmers, in anticipation of an overproduction of the crop, as to cause them to pledge themselves to desist from its production. One of these farmers, looking upon his crop gathered for that year, exclaimed, "I have

done with the cultivation of cotton; there is enough in that gin-house to make stockings for all the people in America." And yet within one hundred years, 1800 to 1900, the production of cotton in the United States has increased from, approximately, 80,000 to 9,345,391 bales, 500-pound standard.

Baling.—The art of pressing cotton has presented to inventors unusual difficulties. Among the recent and more economic methods of baling cotton is the introduction of a bale of uniform size and weight, and possessing greater density. With many of those who advocate the square bale there is a belief that the density of that package may be so increased as to avoid the present necessity of recompression. Already inventions have been made promising this result, but none have as yet come into general use. The present accepted square bale of commerce is 54 inches in length, varying in breadth from 24 to 27 inches, and pressed down to a thickness of 28 to 30 inches.

Out of the efforts to devise superior systems of preparing lint cotton for market have come a great number of inventions for producing packages of various shapes and weights. But of the scores of presses invented during the past five years for baling cotton in cylindrical form there have been only two put into practical operation. One of these is called the Bessonette, or Round Lap, system. By this system the lint, as it comes from the gin, is blown into a storage-reservoir and bat-former, where it is converted into a continuous bat of even thickness, and wound around a cone under a pressure which, light at first, is gradually increased automatically by two rollers operating at opposite sides, until the bale attains its full density. By this steady exertion of an even pressure gradually applied to all the cotton in detail, bales are produced 22 inches in diameter and 35 and 48 inches in length, weighing on an average 270 and 425 pounds respectively. The bales require no further compression, as they possess a density of 35 pounds per cubic foot as compared with a density of 22.5 pounds in the old compressed square bale. This package is self-containing, holding its form and density by adhesion of fibre to fibre and layer to layer, thus avoiding the necessity of iron bands to preserve its shape. The first round-lap-bale press was set up in the United States in 1894. Its

product was much heavier than the present bale, reaching as great a weight as 500 pounds.

Another round-bale process which has come into practical use is known as the Lowry system, and consists in feeding the lint cotton

FIG. 8.—Bessonette Press—Cylindrical Lap-bale.

loose from the gin into a tube surrounded by a cap-plate with a number of slots therein radiating from the centre to the circumference. The bale is first started in the tube by packing cotton therein by hand. When this is done, and a relative revolution of the cap-plate and tube is established, the loose cotton thrown on top comes in contact with that inside the tube and is drawn in through

the slots, and the bale is thus built up endwise. In the Bessonette system pressure is applied from end to end of the bale at two points along the outside circumference, while in the Lowry system pressure is applied only to the end of the bale. The bale turned out by the Lowry press, in its earlier history, like that of the Bessonette press,

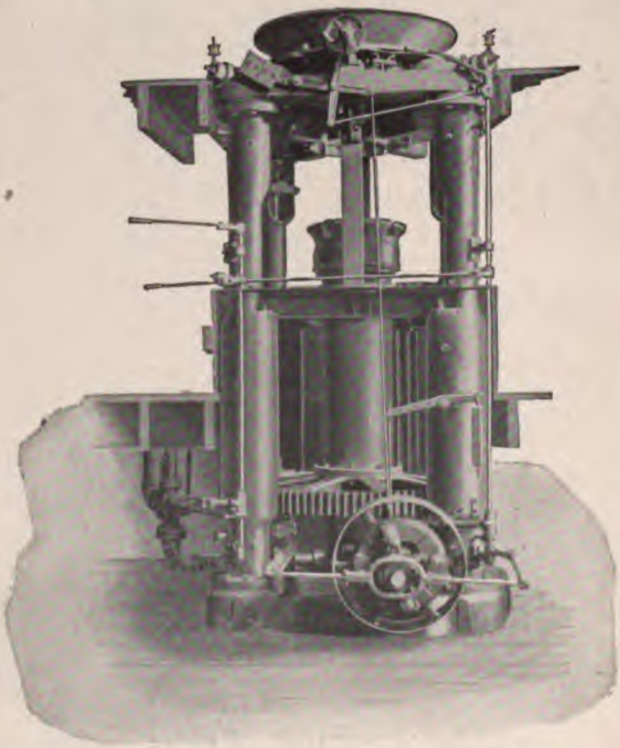


FIG. 9.—Lowry Press—End-packed Cylindrical Bale.

reached a weight of 500 pounds, but with this press also there has been a gradual tendency toward the lighter-weight package, until at this time the average weight of the bale of its new pattern is but 250 pounds. The bale is of uniform size, 18 inches in diameter and 36 inches in length, and possesses a density of about 45 pounds per cubic foot, against 22.5 pounds attained in the compressed square bale.

It is interesting to note that this press is being advantageously employed for baling hay and other fibrous commodities. There have been also more or less successful experiments in ginning cotton with the device, converting the press into a roller-gin. Its successful cotton-packing history may be said to be confined to the past three seasons.*

The Seed.—If a very immature boll be cut transversely, the cut section will show that it is divided by longitudinal walls into three to five divisions, and the seed will be shown attached to the inner angle of each division. The seed retain this attachment until they have nearly reached their mature size and the growth of lint has begun on them, when their attachments begin to be absorbed and by the increased growth of the lint the seed are forced to the centre of the cavity. The development of the fibre commences at the end of the seed farthest from its attachment, and gradually spreads over the seed as the process of growth continues. The first appearance of the cotton fibre occurs a considerable time before the seed has attained its full growth, and commences by the development of cells from the surface of the seed. These cells seem to have their origin in the second layer of cellular tissue and force themselves through the epidermal layer, which seems to be gradually absorbed. The length of the fibre varies considerably on different parts of the seed, being longest at the crown and shortest at the base. Each boll contains from 32 to 36 seed.

The seed are almost hidden by the tuft of white fibre which covers the surface. They are irregularly egg-shaped, from 6 to 9 mm. long and 4 to 5 mm. broad. The thick seed-coat is filled with the coiled embryo, which is sprinkled with brownish resin-glands easily seen with the naked eye. The cells composing the embryo are filled with drops of fat and other matter. The seed contain about 20 per cent. of oil, which for hundreds of years was wasted, for the seeds proper were thrown away after stripping off the fibre. It is only within the present century that they were considered of any value except for planting.

The quantity of seed produced is determined by multiplying

* Report on Cotton-ginning, June, 1902. XII. Census.

the number of pounds of lint cotton by 2, it being an authenticated fact that seed cotton on an average "thirds itself" at the gin. That

FIG. 10.—Branch of Cotton-plant Bearing Bolls in Various Stages of Development.

is, one-third of the seed cotton's weight before it is ginned is lint cotton, and the remaining two-thirds seed.

The types of cotton grown in the United States produce two kinds

of seed, viz.: black seed, from sea-island cotton the limited growth of which is confined chiefly to the islands and shores of South Carolina and Georgia to Florida, from which the staple is easily removed; and green seed, from upland cotton, to which the staple firmly adheres, making reginning necessary, and which constitutes more than 99 per cent. of the total cotton crop.

FIG. 11.—Square and Cylindrical Cotton-bale.

CHAPTER II.

THE COTTONSEED INDUSTRY.

Historical. Statistical.

If there is one aspect more than any other that characterizes modern commercial and industrial development, particularly as we know it in the United States, it is the utilization of substances which in a primitive stage of the development of any industry were looked upon as worthless. They were secondary products incurred in the manufacture of the main commodity, for which the industrial acumen of the age found no use; or if a use were known, the prejudices and conservatism of society allowed them to languish in the shadow of a similar commodity already strongly intrenched.

Nature never plays the part of a spendthrift. In the pursuit of her strong underlying purpose, she provides, not primarily for man, but for the sustenance of the offspring. All the food-products of the vegetable kingdom, from which man draws upon so lavishly, are simply concentrated food in compact form for the nourishment of the future seedling. This material, in most cases, is the part of the plant most desired by man for food. The value of most seed for sustaining human life was early recognized, but the rate at which they have been utilized for this purpose has been dependent upon the simplicity of the technical process necessary for their elaboration, and the demand for them as a marketable commodity in whatever shape the essential ingredient occurred.

The cotton-plant has been cultivated for its seed-hair from the earliest time and throughout a wide geographical area, but it was only in 1783 that the attention of men of modern times was first directed to the fact that the seed, for which the fibre exists as an instrument for its protection and dissemination, contained a useful oil. It appears that in 1783 it was represented in London that oil

might be procured from cottonseed, and a cask of seed was brought from the West Indies and presented to the Society of Arts, then engaged, as ever since, in the Encouragement of Arts, Manufactures, and Commerce. The seed were taken to a mill in the City of London, where the oil was extracted in the presence of the Secretary of the Society and several other persons. Samples of this oil were preserved by the Society. The remainder was used in various experiments to ascertain its qualities. In consequence of these experiments, the following offer of a premium for cottonseed-oil appeared in the Transactions of the Society Instituted at London for the Encouragement of Arts, Manufactures, and Commerce, Vol. I, 1783:

"The Society being informed that a considerable quantity of oil can be obtained from the Seed of Cotton, and that after the expression of the oil, the remaining cake will afford a strong and hearty food for cattle; and likewise that the operation can be applied to the mill for sugar-cane, and worked in the rainy season, at a moderate expense, have resolved, for the foregoing reasons, that the procuring of oil from the Seed of Cotton is the proper object of a premium, considered as an encouragement for planters to extend the cultivation of Cotton, as an article essentially requisite to increase the manufacture of that commodity in this country.

"The Society thereby offer as follows:

Oil from Cotton Seed.

"To the planter in any part of the British islands of the West Indies, who shall express oil from the Seed of Cotton, and make from the remaining seed hard and dry cakes, as food for cattle; the gold medal.

"Certificates that not less than one ton of the oil has been expressed and five hundredweight of the cake obtained, to be produced to the Society, with two gallons of the oil, and two dozen of the cakes, together with a full account of the process, on or before the last Tuesday of November, 1785.

"For the next greatest quantity, not less than half a ton of oil, and two hundredweight of the cakes; the silver medal."

The offer was made in subsequent volumes of the Transactions

and the date postponed. The offer was discontinued after that which appears in Volume VII, 1789. Subsequent records of the Society contain nothing to indicate that its medals were ever awarded or applied for.

Mills, in his statistics of South Carolina published in 1826, says that Benjamin Waring had established an oil-mill in Columbia, and "expressed from cottonseed a very good oil."

The earliest record that we have of the beginnings of the technical utilization of the seed for oil in America appeared in a copy of the Niles *Register* of 1829, from which an extract was made by a New Orleans newspaper and preserved to us by republication in the *Oil, Paint, and Drug Reporter* of New York. The extract runs:

"Cottonseed yields a considerable portion of excellent oil. The difficulty of expressing it, in consequence of the quantity and absorbing quality of the integuments of the kernel, has been so great that heretofore no great quantity of the oil has been made. We are happy to announce that a highly respected gentleman of Petersburg, Va., has invented a machine by which the seed is completely hulled and prepared for the easy expression of its oil. The importance of this invention to the Southern country may be appreciated from the fact that the inventor is erecting a cotton-gin, and will be shortly prepared to gin cotton for the seed only. This invention, as we understand it, consists of a granite cylinder, revolving within convex pieces of the same substance faced and placed in a peculiar manner. A hopper over the stone supplies the seed. A wire sieve under it separates the hull from the kernel. Dropping through a current of air from a wind-fan, it is delivered clean and ready for the press. This machine will probably rank in the country second only to Whitney's gin. About twenty-five years ago Dr. George Hunter, chemist and druggist of Philadelphia, having made some experiments on the oil of cottonseed, thought it worth while to remove to New Orleans, where he carried two steam-engines, purchased from Oliver Evans, the one for the purpose of grinding cottonseed. He did not find the place so well suited to his purposes as he expected, and did not set up his manufactory. Afterward, about 1818, Col. Clark, an ingenious inventor, made some experiments on the oil of

cottonseed for burning in lamps. Oil of cottonseed is selling at Providence, R. I., at 80 cents per gallon."

Harry Hammond states that about 1832 a small oil-mill was operated on an island off the Georgia coast.

Until 1834 cottonseed raised in the United States had no commercial value. The planters used for planting purposes whatever seed they needed, and the remainder was allowed to rot in the fields. In Natchez, Miss., in 1834 the first attempt to crush cottonseed and to extract oil and cake therefrom was made.* The pioneers in the enterprise were Messrs. Jas. Hamilton Cooper and Samuel Plumber of Georgia, assisted chiefly by Messrs. Follett of Norfolk, Va., and Major Anderson Miller of Louisville, Ky. The enterprise was unsuccessful, and after heavy pecuniary loss the idea was abandoned. In Ure's Dictionary, 1843, cottonseed is mentioned in a list of forty-one plants from which oil is obtained, but no further reference is made to it. It was not until 1847 that sufficient interest was aroused to renewed efforts to express oil from the seed, when two citizens of New Orleans, Messrs. Frederick Good and Wilber, attempted to solve the problem, but unfortunately succeeded no better than their predecessors of thirteen years before. It is stated that Mr. Good was wont to exhibit a small bottle of the oil which he said cost him $12,000.

In 1852 Mr. A. A. Maginnis of New Orleans, who was at that time a manufacturer of linseed-oil, crushed a small amount of cottonseed experimentally in his mill, the oil being intended for medicinal purposes and selling at about $1 per gallon.

The extraction of oil from cottonseed in France was advancing much more rapidly. With the naked Egyptian seed and being under no necessity to decorticate it, they successfully expressed oil from them, refined it, and used it for edible purposes.

Mr. Paul Aldigé of New Orleans in 1852 visited Marseilles, the seat of the French oil industry, and familiarized himself with the processes involved. The next recorded attempt to extract oil from the seed in America was made by Messrs. Bradbury and Nautré in 1855, closely followed by F. M. Fisk, P. J. Martin, Paul Aldigé, and

* Statement of Jules Aldigé, June 27, 1882.

A. A. Maginnis, all of New Orleans. The Union Oil Company had at the same time located its mill at Providence, R. I., receiving its supply of seed from the South. So slow was the development of the industry that the Encyclopædia Britannica, 1858, did not include cotton among a list of fifty plants yielding oil. In 1860 there were recorded seven establishments in the United States manufacturing cottonseed-oil.

Prior to 1860 the disposal of cottonseed gave the ginner and the community great concern. The seed was usually hauled to a remote place to rot, or dumped into some convenient stream of running water. With the growth of population and increase in cotton culture this careless method of disposal often became a great nuisance. In this connection, the following extract from one of the laws of Mississippi is interesting history:

"ARTICLE 18. Every owner or proprietor of any cotton-gin erected within half a mile of any city, town, or village is hereby required to remove or destroy all cottonseed which may fall from such gin, so that the same shall not prejudice the health of the inhabitants of such city, town, or village, and every person being an owner or proprietor of a cotton-gin situate as aforesaid who shall neglect or refuse to remove or destroy the cottonseed in and about such gin, having received five days' notice, shall forfeit and pay the sum of $20 for every day he or she shall neglect or refuse to remove or destroy the cottonseed as aforesaid, to be recovered by warrant in the name of the State before any justice of the peace of the proper county for the use and benefit of said county.

"ARTICLE 19. No person who shall be the owner or proprietor of any cotton-gin shall be authorized to throw or permit to be thrown the cottonseed from such gin into any river, creek, or other stream of water which may be used by the inhabitants for drinking or fishing therein; and any person offending herein shall forfeit and pay for every such offence the sum of $200 to be recovered in any court of competent jurisdiction, by action of debt or information in the name of any person who will sue for the same, one moiety thereof to such person and the other moiety to the county in which the offence is committed." *

* Revised Code of Mississippi, 1857, page 207.

The low commercial rating of cottonseed so vividly indicated in this law was current in many localities until the introduction of the intensive system of cotton-farming, which is practically coeval with the introduction of the cottonseed-oil mill; although, in localities where the soil required replenishing, a few thrifty farmers early began the use of the seed as a fertilizer. It was discovered that through the manipulations of the oil-mill all of the value of the seed as a fertilizer was retained, and at the same time it was, through its by-products, made to contribute marvellously to the general economy of wealth. The result is that from a product that was deemed a nuisance in 1857 there was produced in 1900 a value of $42,411,835, and only 53.1 per cent. of the available raw material was utilized.* The Civil War suspended all practical development of the new industry.

The economic stupor of the reconstruction period in the South is attested by the fact that in 1867 there were but four cottonseed-oil mills.

During the war the manufacture of cottonseed-oil was undertaken in New York,† among the first crushers being the Stonewall Oil Company and the Goodkind Brothers. The Glamorgan Company were receivers and refiners, and used the product largely in the manufacture of soap.

The early operations of the new industry were carried on with the greatest secrecy, as though to guard a valuable mechanical secret; but it is now known that no radically new mechanism had been invented, as had been the case in separating the lint, for the extraction of oil from cottonseed. In the main, the machinery and principles long utilized in different parts of the world for the extraction of linseed-oil from flaxseed had merely been adapted to new uses.

To those mentioned previously as engaged in the early development of the industry in New Orleans may be added the names of Capt. D. C. McCann and W. E. Hamilton; while at Memphis, another point at which the industry developed early, the names of Wyley B. Miller, J. W. Cochran, J. C. Johnson, and E. Urquhart

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* XII. Census.

† *Oil, Paint and Drug Reporter.*

are prominent. Among the pioneers at interior points the most conspicuous developers of the industry were George O. Baker at Selma, O. O. Nelson at Montgomery, Robert Thompson at Nashville, and James R. Miller at Little Rock and Memphis.

The number of mills had increased from 4 in 1867 to 26 in 1870. The history of the industry prior to 1870 is one of experiment, in which the applicability of machinery employed in the production of linseed-oil from flaxseed was demonstrated.

In 1880 there were 45 mills; in 1890 there were 119.

With the quite rapid growth of the business in the early eighties, and the improvements that were introduced in the manufacture and refining of the product, came also the necessity for opening up new outlets. The introduction of the oil for edible purposes, at least at the North, may be credited in no small degree to the receivers and brokers here who had the oil to sell and were compelled to force it into any channel that could be opened. The Chickasaw refinery was one of the first to push its oil into consumption in this way, and is closely identified with the progress that was made at the time in widening the field for refined cottonseed-oil. The names of the houses in New York most prominently identified with the industry from the time its development really began, were William J. Bower & Co., both as receivers and brokers; J. F. O'Shaughnessy, Simmonds & Gildemeister, Josiah Macy's Sons, I. & C. Moore & Co., and Thomas G. Hunt & Co., though the list of houses interested in the product rapidly extended with the growth of the manufacturing industry.

Until about 1885 to 1890 the largest sale of cottonseed-oil, except as a soap-making material, was in competition with edible oils consumed in Italy and France, but since then the manufacture of lard compound and oleomargarine has offered an enormous outlet for the oil. Its use as a burning oil has never been large, in comparison with other outlets, although it early found favor as a miners' oil, and to a considerable extent displacing lard-oil in this channel. The popular recognition of the merits of cottonseed-oil as a salad-oil, and for the other finer purposes for which it was used, was very largely due to the labors of the late Lyman Klapp, while John V. Lewis was entitled to the chief credi. for its introduction in the mines.

Among the earliest crushers of the South was Jules Aldigé, who began the industry at New Orleans before the war, and who may be credited more than any other individual with the building up of the foreign demand for American cottonseed-oil. His brands were, for a long time, the most popular in the Continental markets, and the quality of his products gave a permanent standing to this oil as a substitute for the more costly native edible oils in foreign countries, where they are largely consumed as food.

In 1900, according to the XII. Census, there were 357 establishments engaged in extracting crude oil, exclusive of refining plants. In the report of the quantity of cotton ginned in the United States for the crop of 1902 it is stated that "A careful canvass by mail of the cottonseed-oil industry reveals the fact that there are in existence in the United States 618 cottonseed-oil mills."

During the early years of its manufacture cottonseed-oil was almost entirely exported to foreign countries, and export figures for those years represent very nearly the production of the country. As the quantity of cottonseed crushed and the amount of resulting products were not reported prior to the census of 1900, it is impossible to trace directly the statistical growth of the industry, except in so far as it is indicated by exports in the table on page 24.

It is indicated in Table 1 that in 1872 and 1899 cottonseed-oil reached its maximum and minimum prices, commanding in the former year 53.6 cents and in the latter 23.9 cents per gallon in the ports from which it was exported. The low price in 1879 was due to the large quantities of oil obtained from the seed crops of 1878 and 1879. The increase in the production from 281,054 gallons in 1876 to 5,352,530 gallons in 1879 was much in excess of the supply required for the limited field in which it was then utilized. About this time, however, it was discovered that cottonseed-oil could be advantageously combined with beef fat to make a substitute for lard. Then followed the further discoveries that this oil could be utilized in packing American sardines and, in combination with other substances, in making artificial butter. This increased the demand and gave a permanent stimulus to the industry.

In Table 2 from the XII. Census are shown by States and Territories and for the United States the number of establish-

TABLE 1.—EXPORTS OF COTTONSEED-OIL, 1870 TO 1903.*

Year.	Gallons.	Value.†	Average Value per Gallon.
			Cents.
1870	(‡)	$14,946	....
1871	(‡)	140,577	....
1872	547,165	293,546	53.6
1873	709,576	370,506	52.2
1874	782,067	372,327	47.7
1875	417,387	216,640	51.9
1876	281,054	146,135	52.0
1877	1,705,422	842,248	49.4
1878	4,992,349	2,514,323	50.4
1879	5,352,530	2,232,880	41.7
1880	6,997,796	3,225,414	46.1
1881	3,444,084	1,465,255	42.5
1882	713,549	330,260	46.3
1883	415,611	216,779	52.1
1884	3,605,946	1,570,871	43.6
1885	6,364,279	2,614,592	41.1
1886	6,240,139	2,115,974	33.9
1887	4,067,138	1,578,935	38.8
1888	4,458,597	1,925,739	43.2
1889	2,690,700	1,298,609	48.3
1890	13,384,385	5,291,178	39.5
1891	11,003,160	3,975,305	36.1
1892	13,859,278	4,982,285	36.0
1893	9,462,074	3,927,556	41.5
1894	14,958,309	6,008,405	40.2
1895	21,187,728	6,813,313	32.2
1896	19,445,848	5,476,510	28.2
1897	27,198,882	6,897,361	25.0
1898	40,230,784	10,137,619	25.2
1899	50,627,219	12,077,519	23.9
1900	46,902,390	14,127,538	30.1
1901	49,356,741	16,541,321	33.5
1902	33,042,848	12,992,393	39.4
1903	35,642,994	14,211,244	39.8

* Commerce and Navigation of the United States.

† The value of cottonseed-oil, at the time of exportation, in the ports of the United States whence exported.

‡ Quantity not stated.

ments, the quantity and cost of cottonseed crushed for oil extraction, and the quantity and value of each of the products, together with the total value of all products.

Table 3 shows by States and Territories and for the United States the number of establishments, the average consumption of

TABLE 2.—NUMBER OF ESTABLISHMENTS, QUANTITY, COST, AND AVERAGE COST PER TON OF COTTONSEED CRUSHED; AND QUANTITY, VALUE, AND AVERAGE VALUE PER UNIT OF PRODUCTS MANUFACTURED: 1900.

States and Territories.	Number of Establishments.	Cottonseed.		
		Tons.	Cost.	Aver. Cost per Ton.
United States	357	2,479,386	$28,632,616	$11.55
Alabama	27	172,093	2,019,085	11.73
Arkansas	20	190,015	2,245,710	11.82
Georgia	46	271,833	3,246,814	11.94
Indian Territory	6	26,415	297,939	11.28
Louisiana	21	250,983	2,833,767	11.29
Mississippi	41	394,678	4,577,995	11.60
North Carolina	20	107,660	1,313,663	12.20
Oklahoma	6	26,425	247,520	9.37
South Carolina	48	156,642	2,186,408	13.96
Tennessee	15	168,307	1,848,829	10.98
Texas	102	692,604	7,560661,	10.92
All other States *	5	21,731	254,225	11.70

States and Territories.	Products.						
	Total Value.	Oil.			Cake and Meal.		
		Gallons.	Value.	Aver. Value per Gallon.	Tons.	Value.	Average Value per Ton.
				Cents.			
United States.	$42,411,835	93,325,729	$21,390,674	22.9	884,391	$16,030,576	$18.13
Alabama	2,952,254	6,704,951	1,520,834	22.7	60,389	1,076,150	17.82
Arkansas	3,188,812	7,224,971	1,644,465	22.8	65,459	1,142,102	17.45
Georgia	4,787,100	10,606,693	2,468,386	23.3	91,637	1,713,038	18.69
Indian Territory	446,078	931,885	207,251	22.2	9,185	182,807	19.90
Louisiana	4,397,891	9,692,640	2,222,762	22.9	91,348	1,715,424	18.78
Mississippi	6,671,031	15,033,565	3,364,278	22.4	141,529	2,618,405	18.50
North Carolina	1,880,015	4,388,277	979,637	22.3	36,088	678,973	18.81
Oklahoma	410,063	937,021	186,761	19.9	9,481	163,785	17.28
South Carolina	3,043,547	6,162,218	1,545,934	25.1	57,986	1,169,645	20.17
Tennessee	2,737,038	6,454,173	1,363,555	21.1	59,613	1,045,795	17.54
Texas	11,519,656	24,354,695	5,696,263	23.4	252,983	4,371,377	17.28
All other States.	378,350	834,640	190,548	22.8	8,693	153,075	17.61

States and Territories.	Products.—*Continued.*					
	Hulls.			Linters.		
	Tons.	Value.	Average Value per Ton.	Pounds.	Value.	Average Value per Pound.
						Cents.
United States	1,169,286	$3,189,354	$2.73	57,272,053	$1,801,231	3.1
Alabama	80,167	217,925	2.72	4,331,016	137,345	3.2
Arkansas	90,683	248,770	2.74	4,613,519	153,475	3.3
Georgia	132,344	405,581	3.06	6,398,830	200,095	3.1
Indian Territory	13,074	32,972	2.52	673,975	23,048	3.4
Louisiana	114,446	287,650	2.51	6,133,661	172,055	2.8
Mississippi	185,060	396,791	2.14	9,199,737	291,557	3.2
North Carolina	52,139	145,928	2.80	2,149,996	75,477	3.5
Oklahoma	12,424	40,897	3.29	525,550	18,620	3.5
South Carolina	71,542	217,886	3.05	3,223,892	110,082	3.4
Tennessee	79,858	196,105	2.46	4,058,473	131,583	3.2
Texas	328,119	975,489	2.97	15,544,379	476,527	3.1
All other States	9,430	23,360	2.48	410,025	11,367	2.7

* Includes establishments distributed as follows: Florida, 1; Kansas, 1; Missouri, 2; Illinois, 1.

cottonseed per establishment, the average quantity and value of the several products manufactured from 1 ton of seed, and the per cent that each is of the total weight and value.

TABLE 3.—NUMBER OF ESTABLISHMENTS, AVERAGE CONSUMPTION OF SEED, AVERAGE PRODUCTION PER TON OF SEED, AND PER CENT. OF EACH PRODUCT TO TOTAL. XII. CENSUS.

States and Territories.	Number of Establishments.	Average Consumption of Seed per Establishment.	Products. Average Quantity per Ton of Seed.				
			Oil.	Cake and Meal.	Hulls.	Linters.	Waste.
		Tons.	*Gallons.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
United States	357	6,945	37.6	713	943	23	39
Alabama	27	6,374	39.0	702	932	25	48
Arkansas	20	9,501	38.0	689	954	24	48
Georgia	46	5,909	39.0	674	974	24	35
Indian Territory	6	4,403	35.3	695	990	26	24
Louisiana	21	11,952	38.6	728	912	24	46
Mississippi	41	9,626	38.1	717	938	23	37
North Carolina	20	5,383	40.8	670	969	20	36
Oklahoma	6	4,404	35.5	718	940	20	56
South Carolina	48	3,263	39.3	740	913	21	31
Tennessee	15	11,220	38.4	708	949	24	31
Texas	102	6,790	35.2	731	947	22	36
All other States *	5	4,346	38.4	800	868	19	25

States and Territories.	Products. Average Value per Ton of Seed.				
	Total.	Oil.	Cake and Meal.	Hulls.	Linters.
United States	$17.11	$8.63	$6.46	$1.29	$0.73
Alabama	17.15	8.84	6.25	1.26	0.80
Arkansas	16.78	8.65	6.01	1.31	0.81
Georgia	17.61	9.08	6.30	1.49	0.74
Indian Territory	16.89	7.85	6.92	1.25	0.87
Louisiana	17.52	8.86	6.83	1.14	0.69
Mississippi	16.90	8.52	6.63	1.01	0.74
North Carolina	17.46	9.10	6.31	1.35	0.70
Oklahoma	15.52	7.07	6.20	1.55	0.70
South Carolina	19.43	9.87	7.47	1.39	0.70
Tennessee	16.26	8.10	6.21	1.177	0.78
Texas	16.63	8.22	6.31	1.41	0.69
All other States	17.41	8.77	7.04	1.08	0.52

* Includes establishments distributed as follows. Florida, 1; Kansas, 1; Missouri, 2; Illinois, 1.

TABLE 3.—*Continued.*

States and Territories.	Products. Per Cent of Each to Total.								
	Weight.					Value.			
	Oil.*	Cake and Meal.	Hulls.	Linters.	Waste.	Oil.	Cake and Meal.	Hulls.	Linters.
United States....	14.1	35.7	47.2	1.2	2.2	50.4	37.9	7.5	4.2
Alabama.........	14.6	35.1	46.6	1.3	2.4	51.5	36.4	7.4	4.7
Arkansas..........	14.3	34.4	47.7	1.2	2.4	51.6	35.8	7.8	4.7
Georgia..........	14.6	33.7	48.7	1.2	1.8	51.6	35.8	8.4	4.2
Indian Territory....	13.2	34.8	49.5	1.3	1.2	46.4	41.0	7.4	5.2
Louisiana.........	14.5	36.4	45.6	1.2	2.3	50.5	39.1	6.6	3.8
Mississippi........	14.3	35.9	46.9	1.2	1.9	50.4	39.3	5.9	4.4
North Carolina.....	15.2	33.5	48.5	1.0	1.8	52.0	36.2	7.8	4.0
Oklahoma.........	13.3	35.9	47.0	1.0	2.8	45.5	40.0	10.0	4.5
South Carolina.....	14.7	37.0	45.7	1.1	1.6	50.7	38.4	7.2	3.7
Tennessee.........	14.4	35.4	47.5	1.2	1.6	49.9	38.2	7.2	4.7
Texas.............	13.2	36.6	47.4	1.1	1.8	49.5	38.0	8.4	4.1
All other States.....	14.4	40.0	43.4	1.0	1.3	50.3	40.5	6.2	2.9

* Estimated on the basis of 7.5 pounds per gallon.

Table 3 also shows the average quantity of products per ton of seed for the United States in 1900, as follows: Crude oil, 37.6 gallons (equivalent to 282 pounds); cake and meal, 713 pounds; hulls, 943 pounds; linters, 23 pounds; and waste, 39 pounds.

The technical data elaborated in Table 3 relative to the yield of crude oil and oil-cake, the two most important products, make possible an exposition, along broad lines, of many phases of the growth and present magnitude of the cottonseed-oil industry.

Unginned cotton consists of two parts by weight of seed and one part by weight of lint; thus seed- or unginned cotton, "thirds itself" at the gin. Therefore from the total yield of cotton for any given year a fairly accurate estimate can be made of the total crop of cottonseed by multiplying the total yield of lint cotton by two. The quantity of cottonseed raised having thus been ascertained, it is equally well known that under average conditions, as confirmed by Table 3, the yield of the two important products will be oil, about 40 gallons (300 lbs.), and oil-cake, about 700 pounds, from each ton of seed. Thus knowing what proportion of the total cottonseed crop is actually manufactured each year in a gen-

TABLE 4.—COMPARATIVE SUMMARY OF THE QUANTITY AND VALUE OF THE COTTON AND COTTONSEED PRODUCED IN 1899, AND RELATIVE VALUE TO TOTAL CROP OF MANUFACTURED AND UNMANUFACTURED SEED.

States and Territories.	Value of Lint Cotton.	Seed Produced.		
		Quantity.	Value.	Potential Value if Crushed for Oil.
		Tons.		
United States.	*$338,836,921	4,668,346	$54,345,677	$80,371,375
Alabama.	38,826,694	539,260	6,325,520	9,248,309
Arkansas.	25,401,005	352,792	4,170,001	5,919,850
Georgia.	45,958,082	615,530	7,349,428	10,839,483
Indian Territory.	5,169,876	71,804	809,949	1,212,770
Louisiana.	25,212,686	350,176	3,953,487	6,135,084
Mississippi.	44,556,009	618,833	7,184,651	10,458,278
North Carolina.	15,854,380	220,200	2,609,370	3,844,692
Oklahoma.	2,591,384	35,991	337,236	558,580
South Carolina.	30,341,895	418,553	5,843,000	8,132,485
Tennessee.	7,619,073	105,820	1,161,904	1,720,633
Texas.	93,924,632	1,304,509	14,193,058	21,693,985
All other States †.	3,381,205	34,878	408,073	607,226

States and Territories.	Seed Crushed.			Value of Cotton Crop.	
	Quantity.	Cost to the Mills.	Value of Crude Products.	Value of Lint Cotton and Seed.	Potential Value if all Seed were Crushed.
	Tons.				
United States.	2,479,386	$28,632,616	$42,411,835	$393,182,598	$419,208,296
Alabama.	172,093	2,019,085	2,952,254	45,152,214	48,075,003
Arkansas.	190,015	2,245,710	3,188,812	29,571,006	31,320,855
Georgia.	271,833	3,246,814	4,787,100	53,307,510	56,797,565
Indian Territory.	26,415	297,939	446,078	5,979,825	6,382,646
Louisiana.	250,983	2,833,767	4,397,891	29,166,173	31,347,770
Mississippi.	394,678	4,577,995	6,671,031	51,740,660	55,014,287
North Carolina.	107,660	1,313,663	1,880,015	18,463,750	19,699,072
Oklahoma.	26,425	247,520	410,063	2,928,620	3,149,964
South Carolina.	156,642	2,186,408	3,043,547	36,184,895	38,474,380
Tennessee.	168,307	1,848,829	2,737,038	8,780,977	9,339,706
Texas.	692,604	7,560,661	11,519,656	108,117,690	115,618,617
All other States.	21,731	254,225	378,350	3,789,278	3,988,431

* Does not include $313,232, the value of the cotton product of Kentucky and Virginia, there being no oil-mills reported from those States.

† Includes the statistics reported by establishments distributed as follows: Florida, 1; Kansas, 1; Missouri, 2; Illinois, 1.

TABLE 4.—*Continued.*

States and Territories.	Per Cent.			
	Value of Seed Produced to Value of Cotton Crop.	Potential Value of Seed if Crushed to Value of Cotton Crop.	Quantity of Seed Crushed to Quantity Produced.	Increase in Value of Seed by Manufacture.
United States..........	13.8	20.4	53.1	48.1
Alabama................	14.0	20.5	31.9	46.2
Arkansas................	14.1	20.0	53.9	42.0
Georgia................	13.8	20.3	44.2	47.4
Indian Territory..........	13.5	20.3	36.8	49.7
Louisiana................	13.6	21.0	71.7	55.2
Mississippi..............	13.9	20.2	63.8	45.7
North Carolina...........	14.1	20.8	48.9	43.1
Oklahoma...............	11.5	19.1	73.4	65.7
South Carolina...........	16.1	22.5	37.4	39.2
Tennessee...............	13.2	19.6	159.1	48.0
Texas..................	13.1	20.1	53.0	52.4
All other States...........	10.8	16.0	62.3	48.8

eral way, the quantities of the products manufactured therefrom can be determined. The census investigations disclosed the fact (Table 4) that 53.1 per cent of the cottonseed crop of 1899–1900 was utilized in manufacture; the average yield of oil per ton of seed manufactured for the entire country during that year was 37.6 gallons; the yield of oil-cake, 713 pounds per ton. These figures indicate that the commonly accepted commercial estimates upon this industry for previous years were fairly close approximations. Table 5 following, therefore, gives the total cottonseed crop, the percentage of the crop utilized in manufacture, the quantity of seed actually manufactured, the gallons of oil and tons of oil-cake produced, the exports of oil, of oil-cake and meal, and the quantities of oil retained for home consumption from 1872, when exports of cottonseed-oil were first given separately in export statements, up to 1903 inclusive.

TABLE 5.—STATISTICS OF THE COTTONSEED INDUSTRY OF THE UNITED STATES.

Year Ended June 30—	Cotton-seed Crop.	Percentage of Crop Manufactured.	Seed Manufactured.	Oil Produced.	Oil-cake Produced.*	Oil Exported.	Oil Retained for Home Consumption.
	Tons.	*Per Cent.*	*Tons.*	*Gallons.*	*Tons.*	*Gallons.*	*Gallons.*
1872	1,317,637	4	52,705	2,108,000	18,400	547,165	1,560,835
1873	1,745,145	3	52,354	2,094,000	18,300	709,576	1,384,424
1874	1,851,652	4	74,066	2,963,000	25,900	782,067	2,180,933
1875	1,686,516	5	84,325	3,373,000	29,500	417,387	2,955,613
1876	2,056,746	6	123,404	4,936,000	43,200	281,054	4,654,946
1877	1,968,590	5	98,429	3,937,000	34,400	1,705,422	2,231,578
1878	2,148,239	7	150,376	6,015,000	52,600	4,992,349	1,022,656
1879	2,268,147	8	181,451	7,258,000	63,500	5,352,530	1,905,470
1880	2,615,608	9	235,404	9,416,000	82,400	6,997,796	2,418,204
1881	3,038,695	6	182,321	7,293,000	63,800	3,444,084	3,848,916
1882	2,455,221	12	294,626	11,785,000	103,100	713,549	11,071,451
1883	3,266,385	12	391,966	15,679,000	137,200	415,611	15,263,389
1884	2,639,498	15	395,924	15,837,000	138,500	3,605,946	12,231,054
1885	2,624,835	19	498,718	19,949,000	174,500	6,364,279	13,584,721
1886	3,044,544	19	578,463	23,138,000	202,400	6,240,139	16,897,861
1887	3,018,360	23	694,222	27,769,000	243,000	4,067,138	23,701,862
1888	3,290,871	25	822,717	32,909,000	287,900	4,458,597	28,450,403
1889	3,309,564	24	794,295	31,772,000	278,000	2,690,700	29,081,300
1890	3,494,811	25	873,702	34,948,000	305,800	13,384,385	21,563,615
1891	4,092,678	25	1,023,169	40,927,000	358,100	11,003,160	29,923,840
1892	4,273,734	25	1,068,433	42,737,000	374,000	13,859,278	28,877,722
1893	3,182,673	33	1,050,282	42,011,000	367,600	9,462,074	32,548,926
1894	3,578,613	40	1,431,445	57,258,000	501,000	14,958,309	42,299,691
1895	4,792,205	35	1,677,271	67,090,840	587,044	21,187,728	45,903,112
1896	3,415,842	42	1,434,653	57,386,120	502,128	19,445,848	37,940,272
1897	4,070,100	40	1,628,040	65,122,000	569,800	27,198,882	37,923,118
1898	5,252,767	40	2,101,106	84,044,000	735,300	40,230,784	43,813,216
1899	5,471,521	43	2,352,754	94,110,000	823,400	50,627,219	43,482,781
1900	4,668,346	53	2,479,386	93,325,729	884,391	46,902,390	46,423,339
1901	4,830,280	50	2,415,140	96,605,600	845,299	49,356,741	47,248,859
1902	4,983,239	60	2,975,000	119,000,000	1,041,250	23,042,848	85,957,152
1903	5,208,000	60	3,277,233	131,089,320	1,146,532	35,642,994	95,447,326

* Exports of oil-cake since 1895 have been as follows (in tons of 2000 pounds): 1895, 244,858 tons; 1896, 202,468 tons; 1897, 311,693 tons; 1898, 459,863 tons; 1899, 539,996 tons; 1900, 571,852 tons; 1901, 629,343 tons; 1902, 525,233 tons; 1903, 550,196 tons.

CHAPTER III.

SUMMARY OF PROCEDURE OF UTILIZATION OF COTTONSEED.

Receiving and Storing Seed. Cleaning Seed. Reginning Seed. Hulling Seed. Separating Meats and Hulls. Crushing Meats. Cooking Meats. Cake-forming. Oil-expression. Treatment of Crude Oil. Treatment of Cake. Yield of Products per Ton Seed. Economic Considerations. Recent Statistics.

By reference to Fig. 12, in which is shown a diagram of a crude-oil mill, the course of treatment to which cottonseed is subjected may be readily traced. The distribution of power from the main shaft to the various machines by belting is clearly indicated. In Fig. 13 are shown the relative locations of the receiving and storage house for lint cotton, the ginnery, seed storage house, and oil-mill. The latter plan shows the equipment required for the combined enterprises of cotton-ginning and oil-expression for a daily ginnery capacity of 35 to 40 bales with a corresponding daily yield of seed of from 15 to 20 tons. By this plan the seed as they fall from the gins are passed directly to the seed-house. The location of the steam-plant for both ginnery and oil-mill at the latter place removes a potent source of danger from the ginnery. The power required for a ginnery of the capacity stated is from 30 to 60 horse-power; for the oil-mill from 50 to 60 horse-power. An oil-mill with a daily capacity of 15 to 20 tons of seed will consume 2000 to 2500 tons of seed per season of 5 to 6 months' duration. Receiving lint cotton and separating the seed by ginning have already been described. We may pass directly to the seed.

Receiving and Storing Seed.—The capacity of an oil-mill is expressed by the number of tons of seed that can be worked up per day of twenty-four hours. As this varies from 15 to 200 tons and sometimes more, ample storage capacity for receiving and storing

I. Seed-house.
II. Seed-conveyor to reel.
III. Sand and boll-reel.
IV. Blower and magnetic field.
V. Seed-conveyor to delinters.
VI. Delinters.
VII. Seed-conveyor from delinters.
VIII. Seed-conveyor and elevator to huller.
IX. Huller.
X. Conveyor and elevator of meats and hulls to separator and shaker.
XI. Separator and shaker.
XII. Point of delivery of hulls.
XIII. Conveyor and elevator of meats to rolls.
XIV. Rolls.
XV. Conveyor and elevator of meats to heaters.
XVI. Heaters.
XVII. Former.
XVIII. Press.
XIX. Settling-tank.
XX. Storage-tank.
XXI. Duplex hydraulic pump
XXII. Cake-breaker.
XXIII. Mill for grinding cake.

The arrows indicate the direction in which the materia s move.

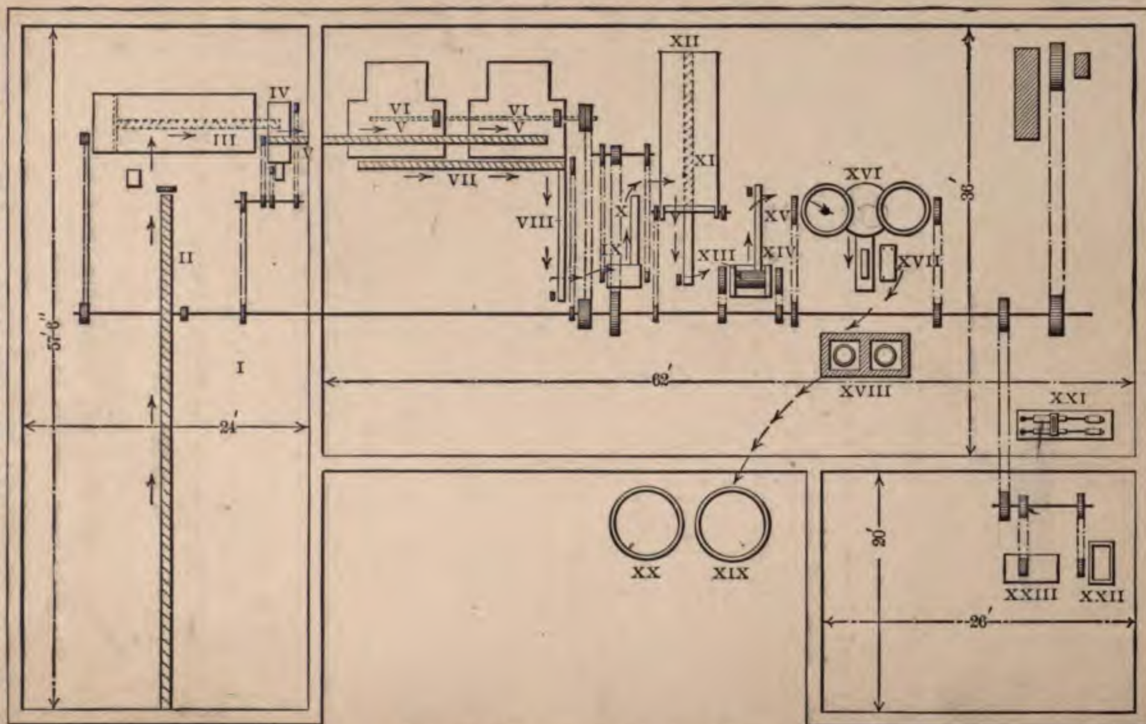


FIG. 12.—Diagram of a Crude-oil Mill.

the green seed is necessary. As the seed deteriorates rapidly in storage its prompt utilization is likewise necessary. The seed may be received from the ginnery by conveyor, if ginning be an associated enterprise, by wagons from neighboring ginneries, or in bags, or loose in box-cars by rail, or in bags by steamboats. The dimensions of the seed-house of a mill capable of handling 15 to 20 tons of seed per day are shown in Fig. 13.

Cleaning Seed.—The seed are mixed with varying amounts of foreign matter which it is necessary to remove. This consists

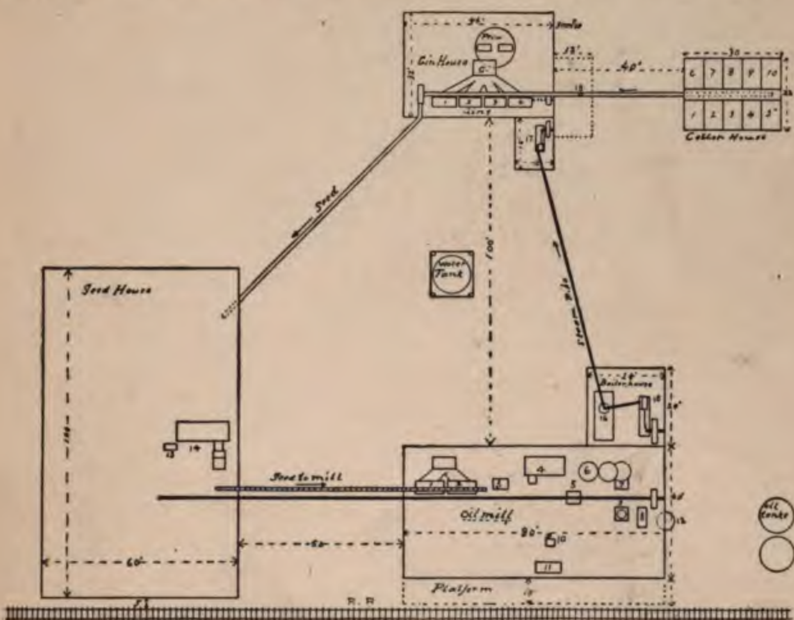


FIG. 13.—Diagram of Ginnery and Cottonseed-oil Mill Combined.

chiefly of sand and dirt, bolls and locks of cotton, sticks and pieces of branches, pebbles, pieces of iron, etc. This separation is effected by means of inclined reels, or revolving screens of heavy wire netting, or perforated sheet metal, a sand and boll screen being shown in Fig. 18. The seed are elevated by bucket-elevator and fed into the higher end of the reel; as they are moved toward the lower end there is a selective separation of foreign matter and seed according to respective size by means of different-sized openings in the net

or metal. Pieces of iron may be separated by means of magnets located in any convenient place in the path of the seed.

Reginning Seed.—In ginning cotton the removal of the staple from the seed is not complete, and a second ginning to remove the greater part of the remaining short fibre or lint is necessary. This is effected by means of delinters, a type of which is shown in Fig. 19. The seed is fed into the delinter and is discharged in a much cleaner state; the delint is condensed in the "condenser" into a broad band which is compressed into bales in the same manner as lint cotton.

Hulling Seed.—In the American practice of oil-milling the seed is decorticated or hulled. This is made necessary by the presence of much adhering fibre, which is absent in the sea-island and Egyptian seed, and which if allowed to remain deteriorates the oil and cake. The pericarp or hull is removed by means of a huller, forms of which are shown in Figs. 20 and 21. The mass discharged from the huller is a mixture of meats, or kernels, hulls and meats with more or less of the hull still adhering.

Separating Meats and Hulls.—The mixture of meats and hulls is subjected to selective separation in the same manner as uncleaned seed and by means of a mechanism of similar construction. A meat and hull separator is shown in Fig. 22. The separation is by no means complete. The revolving screen discharges the greater portion of the hulls at one end and allows the meats to escape through the perforations. Subsequent separation of much of the remaining hulls is effected by means of a shaker, where advantage is taken of the property of hulls with adhering lint to felt together. Hulls may accompany the meats, but meats should not be allowed to go with the hulls. The hulls, formerly used for fuel at the mill, are now highly prized as feeding-stuff and fertilizer. They are conveyed to the hull-house, where they are packed compactly in bags and bales of uniform weight.

Crushing Meats.—From the shaker the meats are conveyed to the feed-box surmounting the crusher-rolls. Crushers of different types and capacities are shown in Figs. 23 to 28 inclusive. The purpose of crushing is to reduce the meats to a uniform consistency, whereby the structure of the kernel is broken down and

the oil-cells ruptured, thus permitting the equal exposure of all parts to heat in the cooking process.

Cooking Meats.—Hereinbefore, in the treatment of seed, the operation has been entirely mechanical, but with cooking there is the intervention of human agency. The success of the cooking process is determined by the judgment and skill of the cook. The cooking is done in shallow, cylindrical, steam-jacketed and covered vessels of cast or sheet iron, called heaters, which vary in number and capacity according to the number of hydraulic presses, both pieces of apparatus determining the daily capacity and efficiency of operation of the mills. Heaters of different types and capacities are shown in Figs. 30, 31, and 32. They are usually operated in pairs, or in series of three or more, according to the capacity and seed supply of the mills, and in such a manner that a continuous supply of cooked meats is available for treatment in the following stage. The procedure followed in cooking is determined very largely by the quality of the seed. The purpose of cooking is to expel the excess of moisture by evaporation, the presence of which is destructive of press-cloth, to heat the oil to facilitate its maximum separation, and to coagulate the albuminous matter of the seed whereby its solubility in the oil is reduced.

Cake-forming.—The cooked meats are transferred directly to the cake-former (Fig. 33), where they are subjected to pressure, just less than is necessary to express oil and formed into cakes approximating the dimensions they are destined to assume. These are wrapped in camel's-hair cloths and inserted at once into the empty compartments or boxes of the hydraulic press.

Oil-expression.—Crude oil is obtained by subjecting the cottonseed, cleaned, hulled, crushed, cooked, and formed into cakes as described, to great pressure by means of a hydraulic press, a type of which is shown in Figs. 35 and 36. The efficient operation of the press and the character of the residue remaining after the separation of the oil, depend upon the care and skill with which the seed is treated in preceding steps and upon the judgment and experience of the press attendant. The products are crude oil and press-cake.

Treatment of Crude Oil.—The crude oil as it flows from the press falls by gravity into a tank beneath. It is dark red to black

in color, due to the dissolved coloring-matter of the seed, and is contaminated with albuminous matter and meal in solution and suspension. It may be transferred to storage-tanks to clarify by sedimentation, or filtered (Fig. 48) at once for the same purpose. The quality of the oil depends upon the quality of the seed. It is subjected to treatment with caustic soda to remove free fatty acids, albuminous matter, and the greater portion of the coloring-matter. The yellow oil thus obtained is clarified by treatment with fullers' earth and yields the edible products. The deposit obtained on settling after treatment with alkali forms the material for the product known as cottonseed-oil soap-stock.

Treatment of Cake.—On release of pressure from the hydraulic press, the cakes, while yet hot, are removed and the cloth stripped from them. The cakes are as firm as a board. Trimming the soft ends is effected automatically (Fig. 54). After cooling, they may be packed in bags of uniform weight and marketed directly, or they may be reduced to meal by grinding, in which state they form a valuable commodity used as cattle-food and fertilizer. An attrition mill for reducing cake to meal is shown in Fig. 57.

Yields of Products per Ton of Seed.—By reference to Table 2 the average yield of products per ton of seed, as reported by 357 establishments engaged solely in the manufacture of crude oil, is as follows:

Crude oil, 37.6 gallons equivalent to..........	282	pounds
Cake and meal...........................	713	"
Hulls...................................	943	"
Linters.................................	23	"
Waste...................................	39	"
Total..............................	2000	"

As these figures represent a broad, general average, it is clear that different seed in the same season, as well as in different seasons, yield varying quantities of products. The better mills from good seed will extract 40 gallons of oil instead of 37.6 gallons, in which case the proportion of the other products, particularly meal, would be reduced. Good, clean, dry seed will yield a greater proportion

of hulls than immature and "sappy" seed; also the proportion of waste would be reduced.

Knowing the prevailing market value of raw seed, together with the factory costs of working up seed per ton (which varies from $3.50 to $4.50), and the prices of the products obtained therefrom, the margin of profit may be readily calculated. The diagram in Fig. 14 shows the various products obtainable from cottonseed and their consecutive position in the procedure of manufacture.

Economic Considerations.—Those establishments engaged exclusively in the manufacture of crude oil are under more economic disadvantages with respect to fluctuations in the price of the raw material than are those who extend the procedure of manufacture to the preparation of edible and manufactured products. It is a fact of common observation that, under the stress of supply and demand, the prices of finished products are more slow to react than the prices of raw materials. An advance in the price of a raw material is not, as a rule, followed at once by a corresponding advance in the price of the finished product. It is likewise true in the utilization of natural resources that as the quality of a commodity is increased the labor cost becomes a correspondingly smaller proportion of the total cost. Applying these axioms to the cottonseed-oil industry, it is clear that the increment of value in manufacturing crude oil is influenced to a greater degree than it is in manufacturing refined oil, by fluctuations in the price of seed.

The tendency of all manufacture, particularly that having to do with products close to the soil, is to gravitate, within certain limitations peculiar to each industry, to the source of supply of raw material. This principle we find expressed in the cottonseed-oil industry in the multiplication of crude oil-mills in close proximity to cotton-growing, hence seed-producing, sections.

In opposition to this economic tendency is that of combination of productive effort. The outcome of these opposing tendencies is indicated by the control of crude oil plants, located at the sources of seed supply, by organizations operating refineries at centrally located points. The increasing, general appreciation of the high value of cottonseed-oil for edible purposes, and of its products as

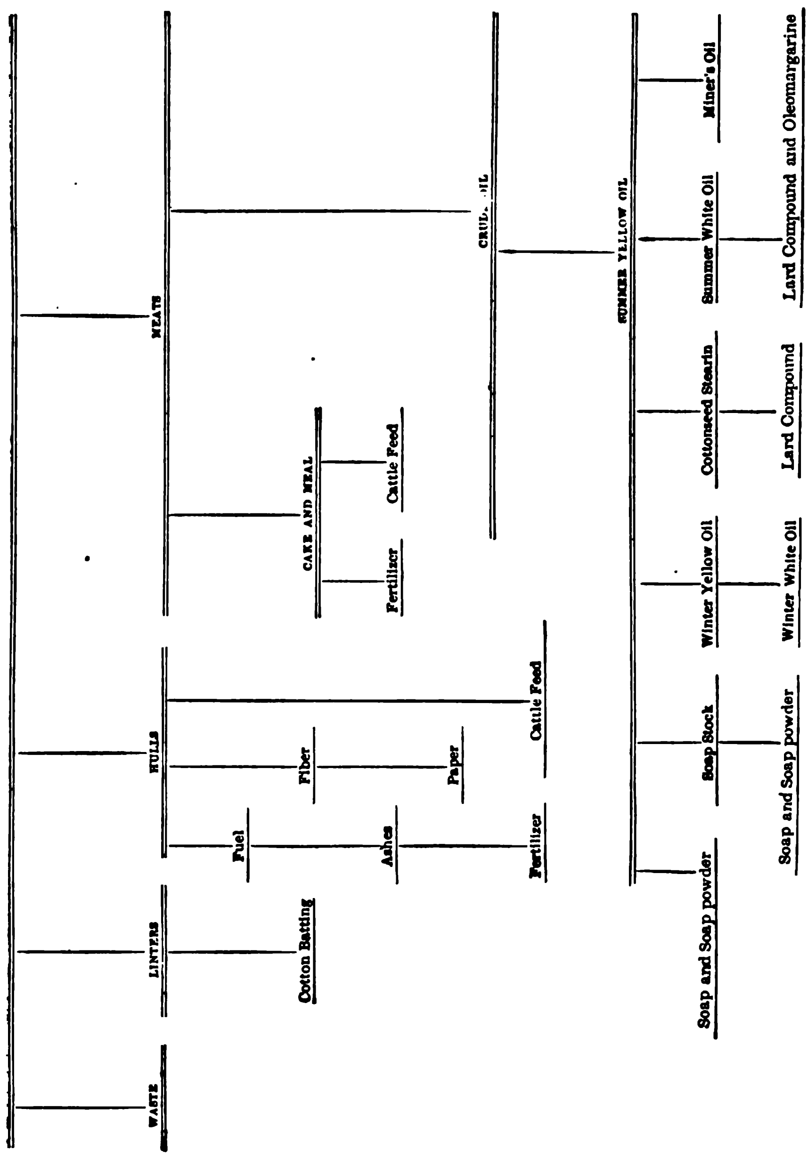


FIG 14.—Diagram Showing Products Obtainable from Cottonseed.

cheap and efficient feed for beef and dairy cattle, promises a most encouraging future for the cottonseed-oil industry.

Recent Statistics.—The Twelfth Census, reporting the industry for the year ending June 30, 1900, found 357 cottonseed-oil mills in operation during the census year, reporting a crush of 53.1 per cent of the seed produced in 1899. The products obtained were valued at $42,411,835. This is a noteworthy growth in the last three years, an increase of 48.6 per cent. in the number of establishments and of 42.2 per cent. in the quantity of seed crushed. The crush for the season of 1902–1903 may be distributed by States and territories as follows:

	Tons.
Alabama	192,438
Arkansas	310,781
Florida	18,601
Georgia	480,557
Indian Territory	74,962
Louisiana	324,229
Mississippi	400,670
Missouri	31,303
North Carolina	222,074
Oklahoma	64,087
South Carolina	280,146
Tennessee	234,682
Texas	872,985
All other States	17,265
Total	3,524,780

Before the general introduction of the cottonseed-oil mill a fair valuation placed upon cottonseed was $6 per ton. The average price paid the producer for seed this season is $15.75 * per ton, an increase of 163 per cent. in, say, fifteen years. The seed sold from the crop of 1902 increased the value of the cotton crop to the farmers by $55,515,285. If the entire seed crop had been thus disposed of, the value would have amounted to $80,209,194.05.

* Census Bull, No. 2, 1903.

The quantities and values of cottonseed products obtained per ton of seed from the growth of 1902 may be distributed as follows:

39 gallons of crude oil, at 30.5 cents per gallon	$11.89
730 pounds of meal, at $20 per ton	7.30
913 pounds of hulls, at $3.50 per ton	1.60
27 pounds of linters, at 3.0 cents per pound	.81
Total value of prducts per ton of seed	$21.60
Less cost of manufacturing per ton	4.00
Net proceeds of ton cottonseed	$17.60

These values would be materially increased by including the value of the meal after it has been converted into fertilizers and the oil after it has been carried through the various channels of refinement. Excluding refineries and fertilizer mills, the total value of cottonseed products this season is $76,233,230, an increase in the value of the seed of $20,717,945, or 37.3 per cent.

CHAPTER IV.

COTTONSEED.

Proximate Composition. Character of the Seed and its Influence upon the Yield and Quality of Oil. Classification. Storage. Handling Seed. Cleaning. Reginning. Hulling. Separating Meats and Hulls. Crushing.

Proximate Composition.—The products of ginning, previously described, are lint cotton and cottonseed. For the former product, ginning is the first step in the mechanical utilization of the fibre in the textile industry; for the latter product, it is the first step in the utilization of the seed for oil and the associated products, linters, hulls, and meal. Seed as received from the gin is covered with a fuzz, or tuft of short hairs, which is the remnants of the fibre not completely removed by the first ginning. Sea-island and Egyptian seed differ from upland cottonseed in the absence of lint, which lint after reginning amounts to about 10 per cent. of the total weight of the seed. Ginned seed is composed of about equal parts of kernel and hull. The kernels yield about 25 per cent. of oil and 75 per cent. of meal. The hulls are composed of 2.2 per cent. of linters and 97.8 per cent. of hulls. The proportions of the commercial ingredients of seed from the gin are as follows:* Meal, 37.5 per cent.; oil, 12.5 per cent.; hulls, 48.9 per cent.; linters, 1.1 per cent. These figures indicate the procedure of division at the time the data were obtained, but are not absolute, as there must be, from the character of the product, more or less variation. By averaging analyses from various sources the following results † were obtained, which represent very nearly the actual weights of different parts of the seed:

* Tenth Census. † Bull. 33, U. S. Dept. of Agr.

Kernels, 54.22 per cent., yielding:	Per Cent.
Oil.	36.88
Meal.	63.12
	100.00
Hulls, 45.78 per cent., yielding:	
Linters.	27.95
Hulls.	72.05
	100.00
In the whole seed:	
Meal.	34.22
Oil.	20.00
Hulls.	35.78
Linters.	10.00
	100.00

Whole cottonseed has been used in the past to some extent as a feeding-stuff, but its use for this purpose has now been practically abandoned in the vicinity of oil-mills, because of the facts that (1) the lint on the seed and the dust it collects are likely to be injurious; (2) it is not easy to mix the seed thoroughly with other coarse feeds; and (3) the seed is disposed of to better advantage at the oil-mills. Its food value is shown by the following summary,* compiled from 25 analyses:

TABLE 6.—FOOD CONSTITUENTS OF COTTONSEED.

	Fresh, or Air-dry, Material.					
	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Minimum	8.00	2.89	13.62	17.60	7.58	10.40
Maximum	17.51	8.00	29.70	32.40	36.70	29.34
Average	**9.92**	**4.74**	**19.38**	**22.57**	**23.94**	**19.45**

The digestible food ingredients in 100 pounds of cottonseed, as determined in a number of digestion experiments, are as follows:

* Bull. 36, U. S. Dept. of Agr.

Dry matter, 89.7 pounds, of which the protein is 11.08 pounds; carbohydrates, 33.13 pounds, and fat, 18.44 pounds.

Protein is a term used to include nominally the total nitrogenous substance, which consists of a great variety of chemical compounds which are conveniently divided into two classes, viz., proteids and non-proteids. Actually the term is used to designate the product of the total nitrogen, ascertained by suitable analysis, by an empirical factor, 6.25. As the proteids contain about 16 per cent. of nitrogen, this factor is generally accepted for bodies of this class.

Fibre is a term applied to substances allied to carbohydrates, but insoluble in dilute acids and alkalis. They constitute the frame-work of plants and are, as a rule, the most indigestible constituent of feeding-stuffs.

Nitrogen-free Extract includes all carbohydrates, as starch, sugar, gums, etc., which constitute the most important part of all feeding-stuffs. In analysis it is determined by difference.

The term "fat" is applied to substances of mixed character forming the ether extract, and may include besides real fats other bodies, as waxes, coloring-matter, lecithins (nitrogenous fats), etc.

Formerly, whole cottonseed was extensively used as a fertilizer in the South, care being taken to kill the seeds by causing them to ferment either in compost heaps or simply in large piles kept wet; but this practice has been largely abandoned, the seeds being disposed of at the oil-mills either for cash or in exchange for meal at the rate of 1 ton of seed for 800 pounds of meal. The following summary, prepared from the results of 15 analyses, will serve to indicate the fertilizing value of cottonseed:*

TABLE 7.—FERTILIZING CONSTITUENTS OF COTTONSEED.

	Water.	Ash.	Nitrogen.	Phosphoric Acid.	Potash.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Minimum	7.04	2.80	1.96	0.76	0.73
Maximum	9.51	4.96	5.17	1.77	1.63
Average	**8.42**	**3.78**	**3.13**	**1.27**	**1.17**

* Bull. 36, U. S. Dept. of Agr.

Character of the Seed and Its Influence upon the Yield and Quality of Oil.—The cotton-plant requires from five and one-half to six and one-half months for maturity, and under the various conditions affecting the growth, uniform quality of seed is hardly to be expected. The quality of the seed, aside from varying degrees of maturity at the time of picking, viz., unripe, half-ripe, and ripe, is a resultant of conditions prevailing during the growth of the plant and of the time and nature of storage before the seed is treated for oil. Quality of the seed is the most important consideration of the cottonseed-oil miller, for the quality of the raw material determines not only the quality of the oil expressed from it and the percentage-yield of oil as well, but it affects also the quality and yield of the products obtained from the crude oil. Inferior seed invariably produces inferior crude oil. The working up of inferior seed in varying proportions with good seed and depending upon skill of manipulation in subsequent processes to correct its deteriorating influence, is largely practised, but involves great danger to the quality of the resulting products. It is the concensus of best opinion that all seed should be graded and each grade milled separately. While there may be a commercial bias to this opinion its influence on the manufacturing side should not be lost.

The presence of moisture in cottonseed is determined by soil and climatic conditions and by the degree of maturity. Seed obtained from the first pickings of cotton contain a greater proportion of moisture than do seed from cotton picked later in the season. Seed grown in middle and lower Texas, owing to the dryer climate, contain very little natural moisture. This is also true to a degree of Mexican and South American seed. Seed from cotton-growing sections east of the Mississippi, particularly that grown in northern portions of the cotton belt and on river-bottoms, contain more natural moisture. The character of the seed with respect to moisture is a most important factor in its manipulation, as will be dwelt upon.

Classification.—Seed may be classified according to their degree of maturity as unripe, half-ripe, and ripe, and according to their degree of inferiority as wet, musty, or rotten. As seed are composed of unstable organic compounds, their deterioration, espe-

cially when in bulk, under the combined influence of heat, moisture, and air, is very rapid. According to rules governing transactions in cottonseed products, cottonseed are divided into two general classes: prime seed and off seed. Prime seed shall be clean, dry, sound seed, free from dirt, trash, and bolls. Seed not coming up to the requirements of prime seed shall be considered off seed. Off or damaged seed shall be settled for on their merits and comparative value as against the value of standard prime seed.

Storage.—The influence of the character of the seed upon the quality of the oil renders imperative the greatest care in their selection and storage. Seed that has undergone any amount of heating will not produce prime crude oil. For this reason as much of the seed as is practicable should be stored in bags to give ventilation. The bags commonly in use are coarse "Dundee" and "Burlap," and hold from 100 to 150 pounds. When stored in bulk cottonseed occupy about 80 cubic feet per ton, although they can be loosely stored to occupy 90 cubic feet, or packed into 65 cubic feet. As the smallest mills crush about 15 tons of seed per day and the larger ones over 200 tons, considerable storage space is required. Seed from the whole crop are ready for the mill by the end of December and always suffer damage by exposure. As stated, they are a very unstable product, for even the pressure of the mass, if stored in bulk, especially if any portion of them have been trampled on and crushed, suffices to cause heating and a rapid fermentation in the damp seed as they come from the gin, which either destroys the kernel entirely or renders it fit to produce only oil and meal of inferior quality. Seed in storage should be kept cool and dry. No plan has yet been devised to preserve them in large quantities, and rapid handling is necessary. Oil-mills maintain seed-houses and scales at railroad stations and employ agents to purchase seed as the wagons bring them from the gins. They are stored and, as occasion offers, shipped in bulk in box-cars. Smaller mills obtain most of their seed directly from the gin by wagon.

Handling Seed.—Throughout the construction of a cottonseed-oil mill, the difficulty of seed-clogging spouts and passageways must be confronted. The seed are covered with lint, left by the cotton-gin, which prevents them from flowing freely like corn, wheat,

etc. Inclined passageways, or chutes, should not be at a less angle than 45°, and then it is necessary to have plenty of room. The adhering lint tends to hold the seed together when in bulk, and effectually precludes the use of any hopper or bin where they may be expected to accumulate and flow out freely.

For horizontal transference of seed, spiral steel conveyors of the type shown in Figs. 15 and 16 are commonly used. They vary

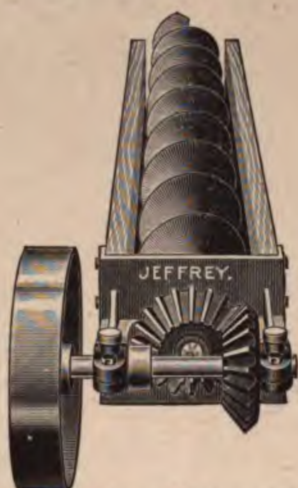


FIG. 15.—End Drives of Horizontal Conveyor.

in size from 6 to 16 inches in diameter, and in speed according to the quantity of seed handled and the time in which it is desired to transport them. The direction in which the seed are moved depends upon the direction in which the conveyor is made to revolve. The manner in which power is applied, corners turned, and the construction and lining of the conveyor boxes, are shown in Figs. 15 and 16. For vertical transference, elevators, of which various types are shown in Fig. 17, are used. These consist essentially of single or double sprocket-chains, or leather or cotton belts, moving upon specially constructed sprocket-wheels or pulleys located at the points of receipt and discharge of the material to be elevated. The buckets, which may be of various shapes and sizes, are attached at uniform distances to the chains or belt. The capacity of an elevator is determined by the size and number of buckets and the speed at which

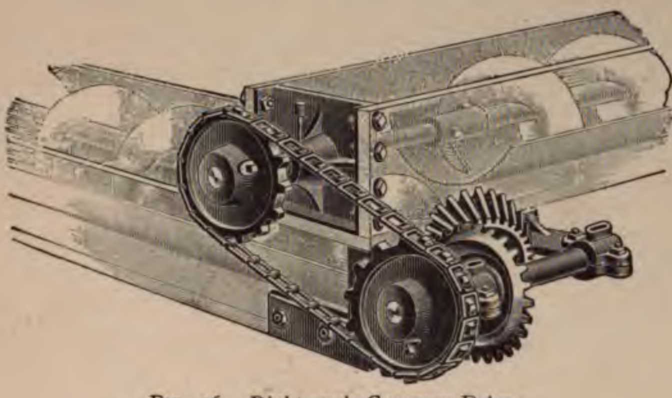
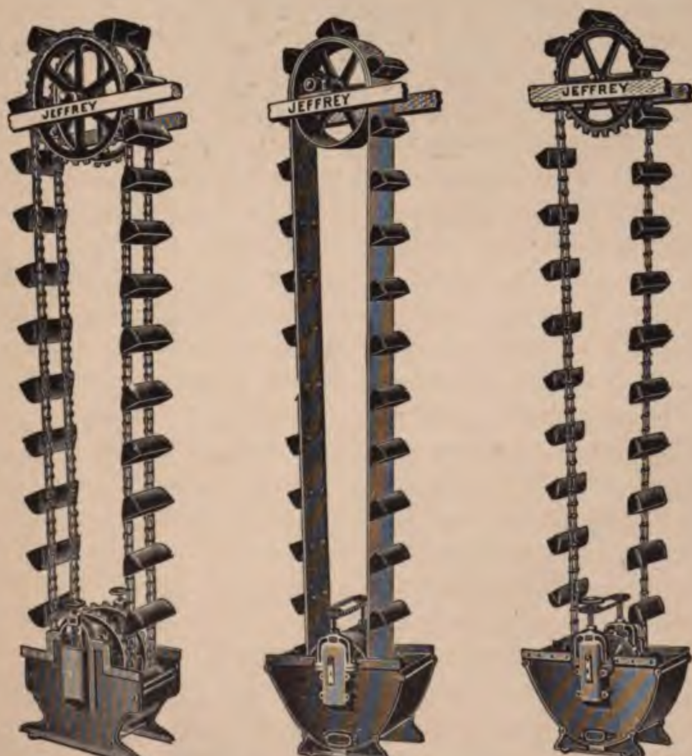


FIG. 16.—Right-angle Conveyor Drives.



Double Strand. Belt. Single Strand.

FIG. 17.—Types of Bucket Conveyors.

the chain or belt is moved. The elevator is surrounded by a dust-proof case which is attached to a hopper or box at the bottom, into which the material to be elevated is discharged, and into which the empty buckets dip as they descend.

Cleaning.—The seed as received from the gin are contaminated with varying amounts of foreign matter, as bolls, flocks of lint, pebbles, sand, earth, twigs, leaves, nails, bolts, bits of metal. pieces of wood, etc., which must be removed. The seed are transferred by elevator and conveyor from bins in the storage-house to the boll-screen. This is an inclined revolving screen or reel of cylindrical or hexagonal cross-section, with perforations sufficiently large to allow seed and foreign matter of equal bulk to fall through, while foreign matter of greater bulk is discharged at the farther and lower end from the feed. The boll-screen may be made of perforated metal or coarse wire netting, and makes about 20 revolutions per minute. From the hopper beneath the boll-screen, the seed with foreign matter yet unseparated are transferred to a smaller screen similar in construction and operation. Here the perforations being smaller, the seed are retained, while sand and earth fall through. The screens vary from 3 to 5 feet in diameter, and from 8 to 18 feet in length. In some mills one screen, made of two sections of netting of different mesh, is made to answer (see combined sand- and boll-screen, Fig. 18), but where ample cleaning capacity is desired, the arrangement is for two screens as above described. From the sand-screen the seed are transported to a blower where foreign matter still retained is separated by means of a current of air. The final step in the mechanical cleaning of the seed consists in blowing the seed in a thin layer upon magnetized bars or plates, which serve to remove fragments of metal, nails, etc., which have escaped separation in the preceding steps. Matter collected in this way is removed from time to time.

In this preliminary mechanical treatment of the raw seed the loss in weight arises from two sources, viz., separation of mixed foreign matter and evaporation of natural moisture of the seed. It amounts to about 6 per cent. of the weight of the original seed. With green, damp, or very dirty seed, the loss in weight will exceed this. Imperfect removal of foreign matter results in abuse of the

linter saws, requiring their frequent removal for sharpening and repair. The physical character of mixed cottonseed is affected to a large degree by its geographical origin and the practice of ginners.

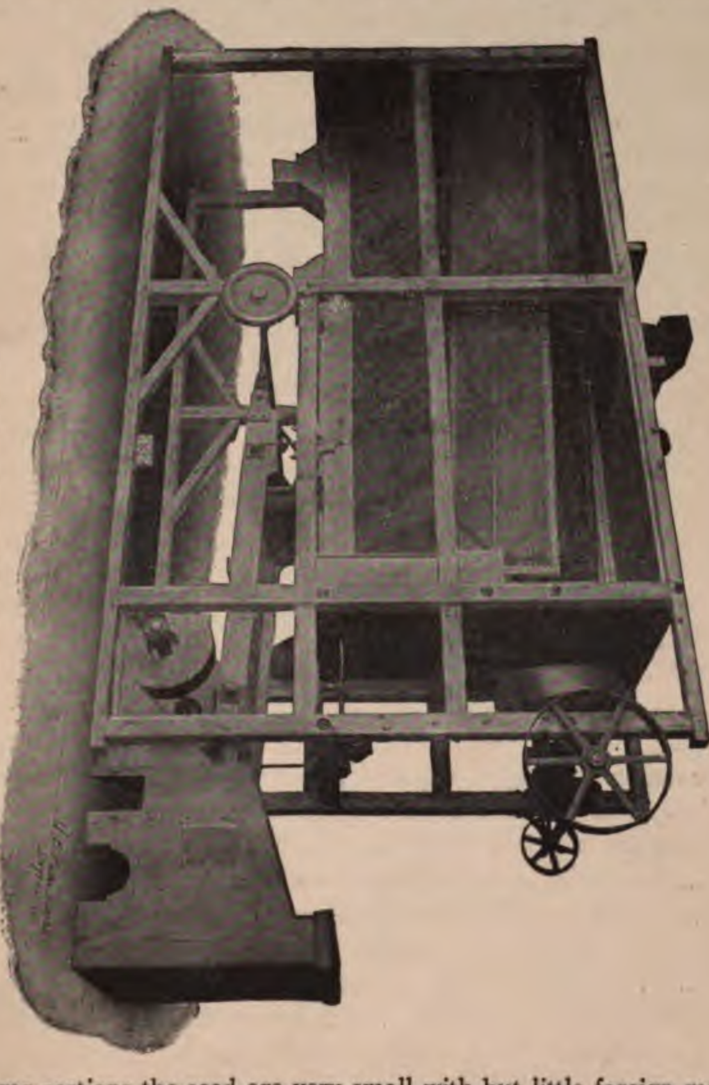


FIG. 18.—Sand- and Boll-screen.

In some sections the seed are very small with but little foreign matter; in others the seed are very large with much foreign matter. This is especially true of seed from the Mississippi and Red River

sections. Some ginners add all refuse from the condensers to the seed. Where lack of care in this respect is practised, large waste is experienced, as high as 250 pounds per ton, and large screening surface is required.

Reginning or Delinting.—The delinter (Fig. 19) is similar in construction to the gin for seed cotton described on page 6, but the saws are set more closely together and with finer teeth, mechanical conditions made necessary by the shortness of the fibre to be removed. Instead of 60, 70, or 80 saws as in the ordinary gin, 106 are the usual number. An electromagnet may be attached to the hinges which hold the feed-board of the delinter, or the magnet may take the place of the feed-board. The poles of the magnet extend across the entire length of the board, thus presenting a very powerful and uniform magnetic field.

The advantage of this position is very apparent, as the seed pass over the magnet slowly and evenly, thus enabling the magnet to catch all metallic substances, large or small.

The magnet is in full view of the man who is in charge of the linters, and he can easily remove all metals from the magnet, so there will be nothing to prevent an even flow of the seed.

The destructive effect of any metallic object upon the saws of the delinter renders the necessity of precaution of this nature very apparent. The purpose of delinting is to remove more completely the short fibres which form the "linters." Their removal improves the quality of oil and cake, makes the seed easier to handle, retards fermentation if storage is required, and improves the hulls for stock-feeding. The products of delinting are the linters, which pass to the condenser attached to the delinter, where they are formed into rolls which are removed at intervals and baled, and the seed, which are now ready to be hulled or decorticated.

It is not desired in American practice to completely separate all fibre from the seed, as the portion allowed to remain assists in the separation of the meat or kernel from the hull. With faulty manipulation, however, a second delinting may be necessary. Sea-island cotton is entirely freed from lint by the first ginning, and is, therefore, not reginned at the oil-mill. Upland cottonseed vary in the quantity of lint which remains after the first ginning, some

carrying considerable lint, while other seed approach very closely the condition of the sea-island variety. Table 3 shows that the quantity of lint secured by the oil-mills from the necessary reginning of the seed varied from 19 to 26 pounds per ton, and that the average for the United States was 23 pounds per ton. Linters, or delint, as the short fibre is also called, find extensive application in the arts, and are available for most purposes for which ordinary lint cotton

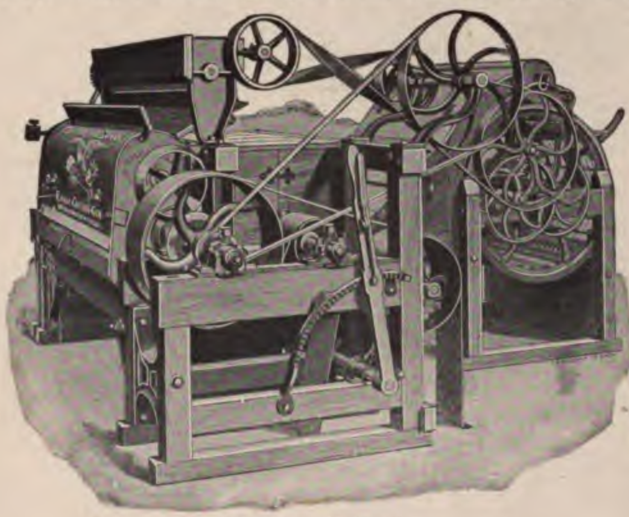


FIG. 19.—Delinter.

is used, but command a much lower price. Paper, hats, carpet yarns, and cheap cloth represent the chief consumptive outlets.

Hulling.—Hulling, or decorticating, has always been a very difficult process, owing to the varying conditions of the seed. When it is thoroughly dry and free from an excess of lint, it is not so hard to accomplish, as then the hull is easily broken and kernel, or "meat," is loose and drops out of the cracked hull. But when the seed are not well matured, damp, and soft the hull will not break, but mashes so that it is hardly possible to get the meats from the hull, and under such conditions seed must be *cut* and not *mashed*.

The huller (Figs. 20 and 21) consists essentially of two concentric cylinders, the outer one stationary and the inner one attached to a shaft carrying a pulley by which power is applied. The inner cylinder carries knives set into its circumference. These knives, 9 to 17

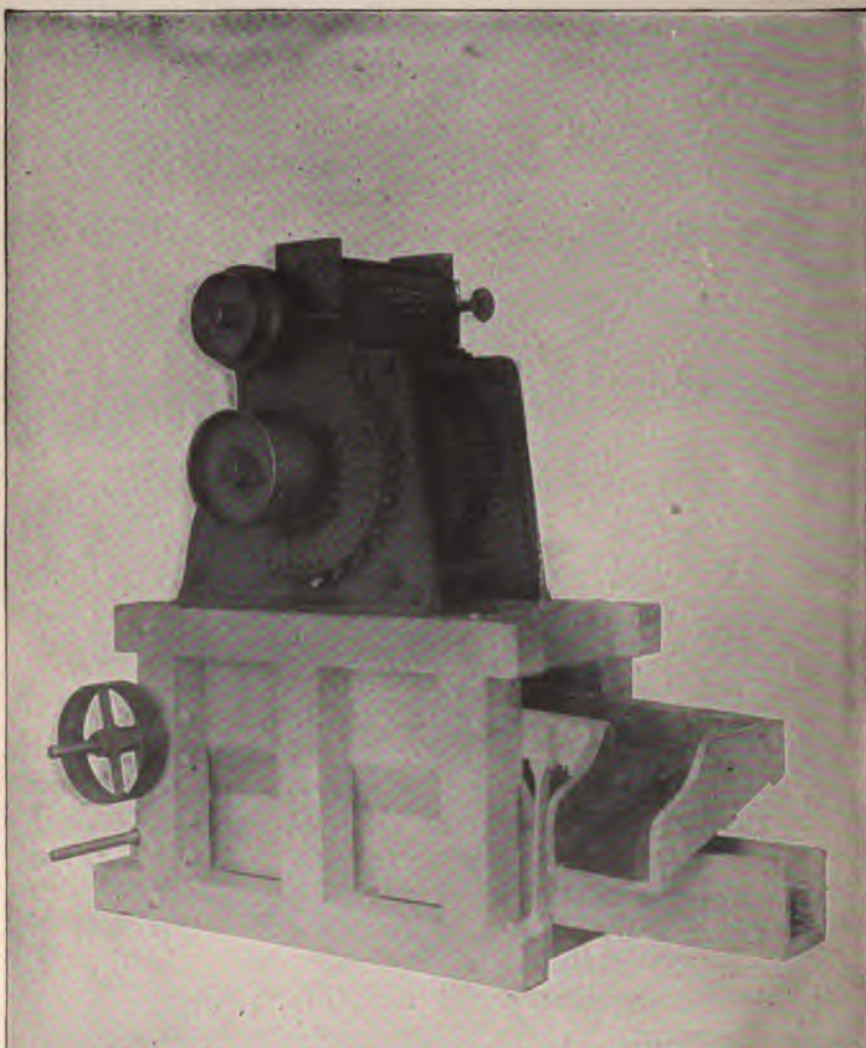


FIG. 20.—Cottonseed Huller Mounted on Frame.

in number, according to the capacity and construction of the huller, are called "cylinder" knives, in contradistinction to the "breast" or "concave" knives, set into the concavity of the outer, stationary cylinder. The breast knives are adjustable and can be set a

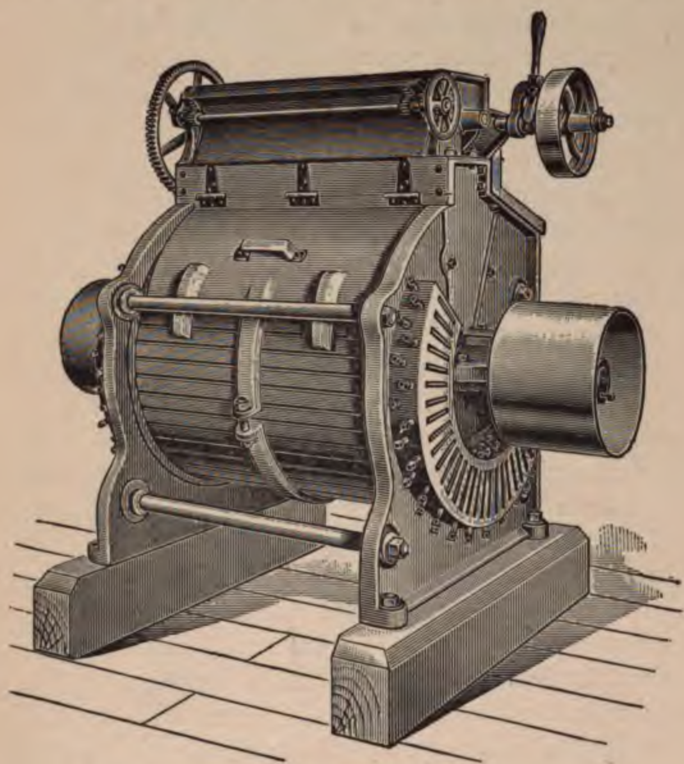


FIG. 21.—Cottonseed Huller.

desired from one thirty-second to three-sixteenths of an inch from the periphery of the revolving cylinder knives. The huller proper is surmounted by an adjustable feeder, which admits of a regular and uniform feed and is provided with a clutch by means of which the feed may be varied at will. The inner cylinder revolves at high speed, usually 1100 to 1200 revolutions per minute.

The purpose of the huller is to loosen and detach the hull, or pericarp, from the kernel of the seed. This it does by cutting and cracking, with sound, dry seed, the hard and brittle hull.

The hullers do not, as a rule, remove the endocarp, or outer skin—i.e., the membrane between the shell and kernel. The endocarp for the most part remains on the kernels and is disintegrated when they are passed through the crusher-rolls and reduced to a uniform meal.

The cylinder knives must be kept true with the cutting edge. In setting cylinder knives, first put in all the knives; then set the knife that has the longest edge to the top breast knife so that it jus clears and is parallel with the edges; then pack up with paper all the other knives, until all cutting edges are true in circumference. The edges of the cylinder knives must form a true circumference to do good work, and must be firmly attached to the cylinder. The breast knives do the cutting, and should be kept sharp, and the first two of which that receive the seed should be set back a little more than the others. The discharge must be kept free so that the seed is not carried around the second time or more after being cut. If the huller is not properly set or speeded, all the seed will not be cut and whole seed may pass through.

The meats with the adhering cracked and detached hulls are discharged from the huller and conveyed by elevator to the meat and hull separator.

Separating Meats and Hulls.—For this purpose a device, a form of which is shown in Fig. 22, is employed. It closely resembles the boll-screen (Fig. 18) in construction. A reel covered with a wire screen revolves about 20 revolutions per minute. The mass of chopped seed, meats, and hulls discharged from the huller are elevated to the top of the casing inclosing the screen and discharged upon it. The meshes of the wire screen effect a separation of hull and meat by allowing the latter to pass through the screen, while most of the hulls collect in the screen and are discharged from one end and conveyed to the hull-house. The meats are discharged from the hopper beneath the screen upon the shaker, or oscillator, oscillating about 250 times per minute. The lint adhering to the hulls that remain with the meats causes them to "felt" together in wads as they are tossed upon the shaker and prevents them from falling through with meats as they are sifted out. Naked seed, notably from Egyptian and sea-island cotton, do not permit of as

thorough a separation of meat and hull, owing to the absence of lint, and as a result oil and cake made from them is of inferior quality. By reference to Table 3 it will be seen that the average yield of hulls from 2000 pounds of seed in the United States is 943 pounds.

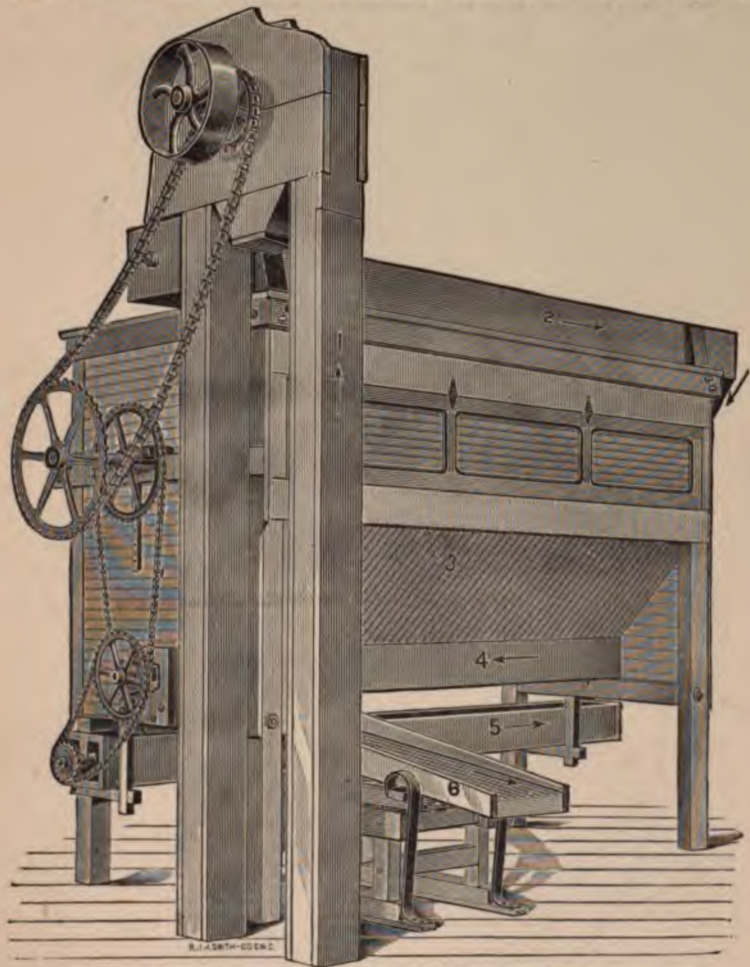


FIG. 22.—Meat and Hull Separator.

Crushing.—The purpose of crushing is to rupture the oil-cells, and to so break down the structure of the kernel that all parts may be equally exposed to heat in the cooking process, whereby the mass is thoroughly and uniformly softened, thus permitting the freest egress

of the oil in the press. Crushing is effected by means of chilled-iron rolls of different sizes and methods of driving. Crushers vary in capacity according to the number and length of the individual

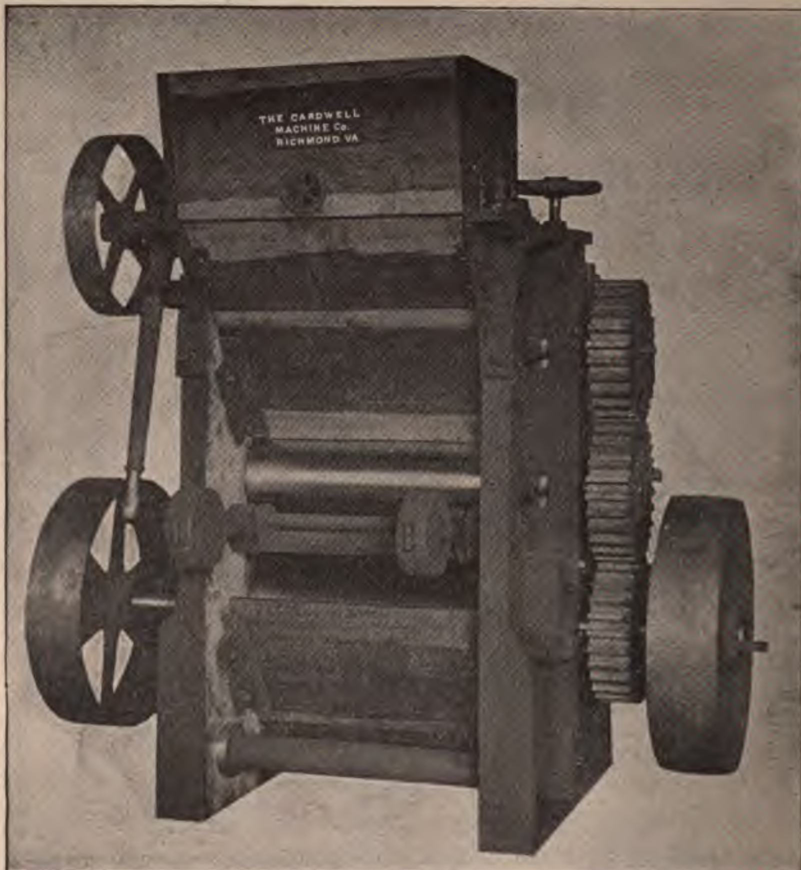


FIG. 23.—Three-high Geared Crushers.

rolls, which may vary from 3 to 5 in number and from 2 to 5 feet in length. Individual rolls vary in diameter from 12 to 16 inches. In Figs. 23 and 24 are shown respectively three-high geared and five-high belted crushers. In Figs. 25 to 28 inclusive additional types are shown. The faces of the rolls are hard and ground absolutely true. The steel scrapers are held against the

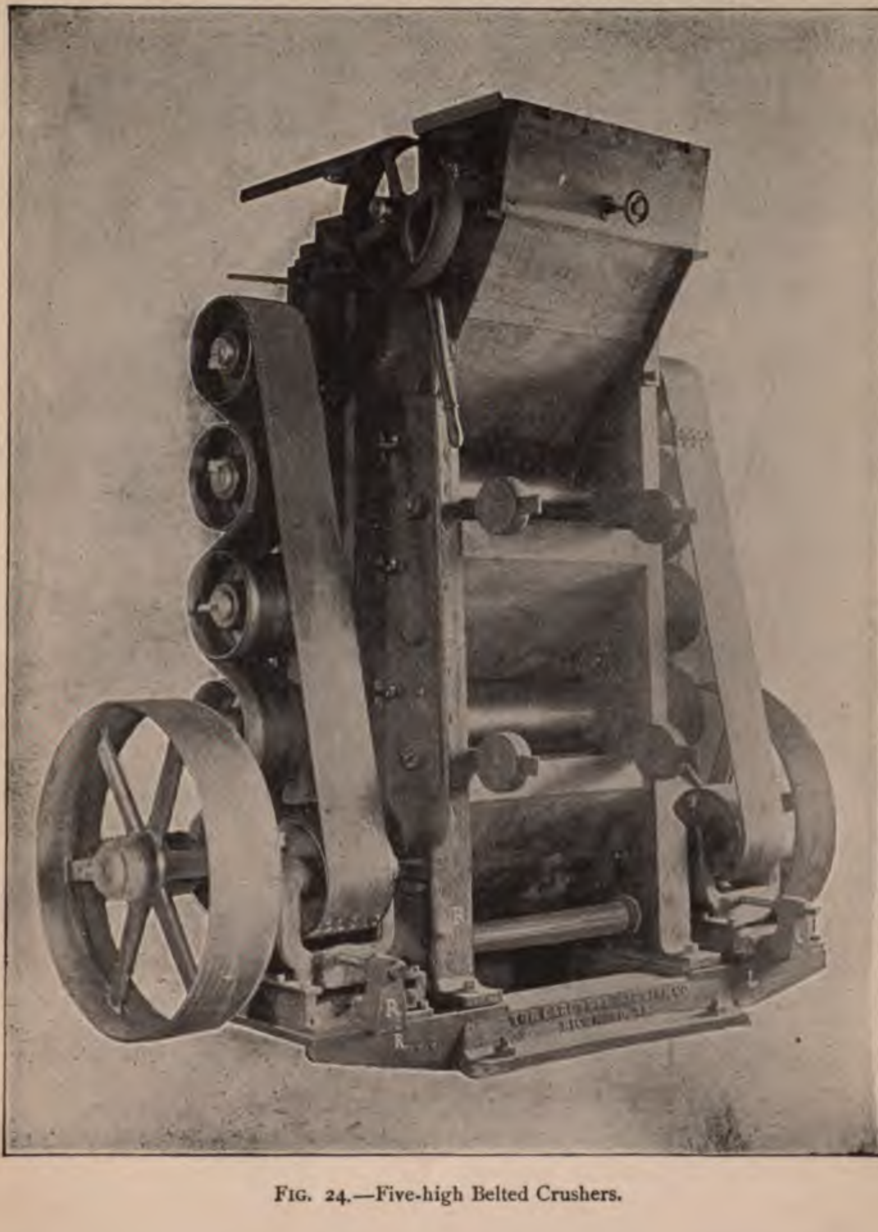


FIG. 24.—Five-high Belted Crushers.

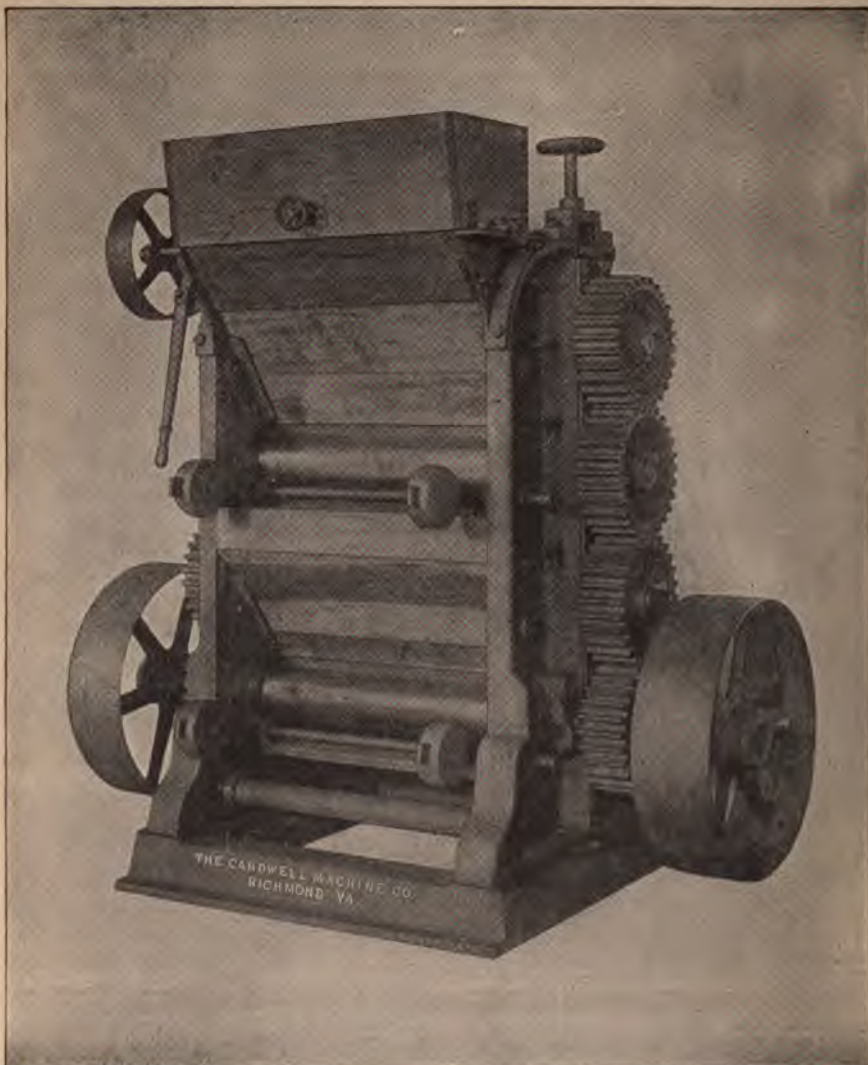


FIG. 25.—Four-high Geared Crusher.

rolls by adjustable weights. The rolls are held together by heavy coil springs which give sufficient pressure to thoroughly crush and break the oil-cells, but will yield and allow any pieces of metal that

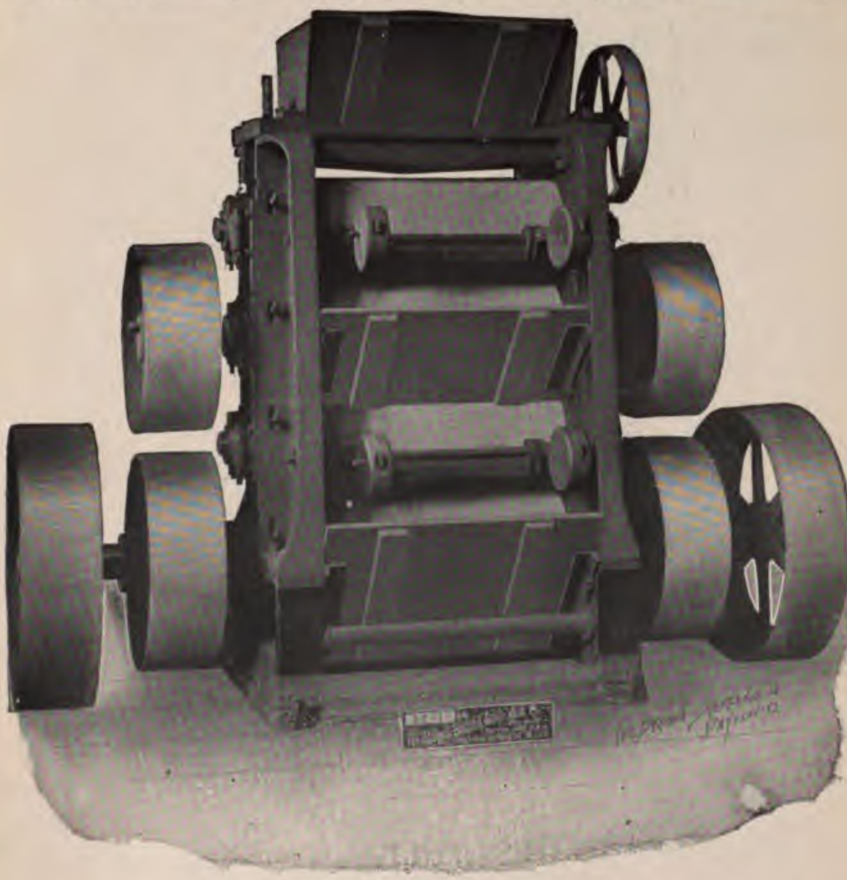


FIG. 26.—Four-high Tandem-belted Crusher.

might possibly get in with the meats to pass through without injury to the rolls. The crusher is surmounted by a feed-box in which is a fluted roller, driven by a belt, that feeds evenly and regularly the entire length of the roll and has a clutch so that it may be shut off instantly in case of a sudden stop.

The cleaned kernels are carried by conveyor from the oscillator to the feed-box above the crusher, whence they are evenly distributed

in proper quantity to the rolls and pass in succession between each pair of rolls whose smooth hard surfaces and heavy weights mash them into thin flakes, crushing every oil-cell.

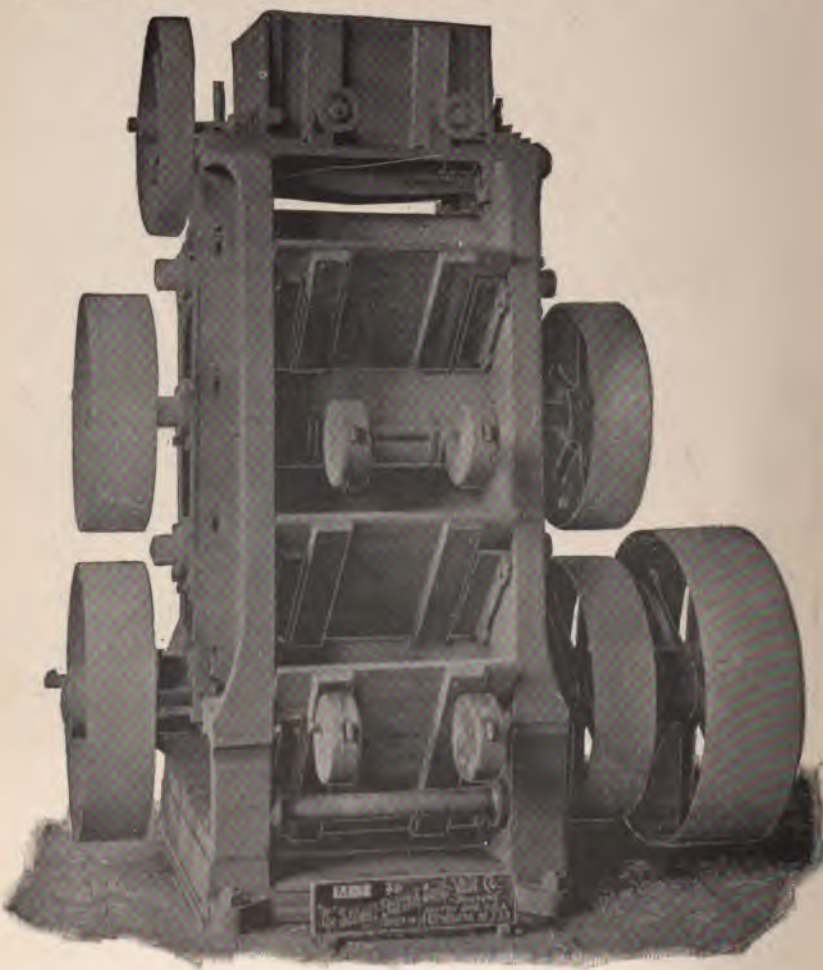


FIG. 27.—Four-high Tandem-belted Crusher. Driven on One Side.

It is very important that the crushers be operated properly and that a uniform, uninterrupted feed be kept upon the rolls. Any delinquency whereby the meats are imperfectly ground as a result of hasty, irregular, or intermittent feeding affects materially the

yield of oil in the press. All sweepings of uncrushed kernels should be returned to the separator shaker and not allowed to go in with the crushed meats. When the meats are uniformly well crushed and soft, the cooking is more efficiently done and the oil separated in the press more easily and in larger proportion. The roll should

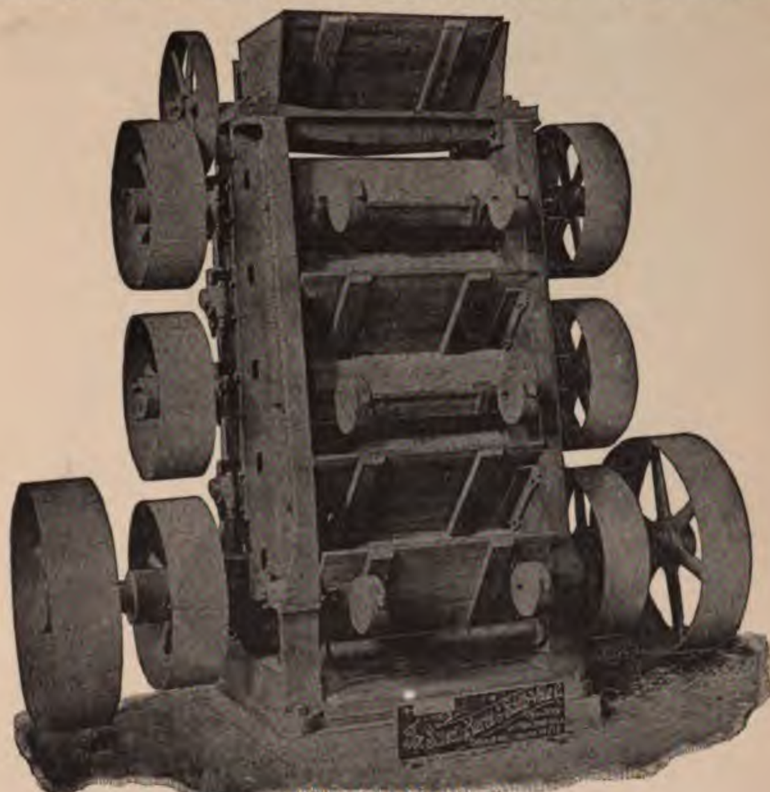


FIG. 28.—Five-high Tandem-belted Crusher.

run about 175 revolutions per minute. With thoroughly cleaned meats the efficiency of the extraction process is determined by the care and skill with which the crushing is done. Improperly crushed meats mean inefficient cooking; inefficient cooking means a low yield of oil of inferior quality and wasteful use of filter-cloths; inferior oil means large waste on refining and reduced yield of successive grades of refined oil.

Too much stress cannot be laid upon the care with which each step in the manipulation of the seed is performed. The steps previous to and including crushing are mechanical; succeeding crushing, chemical influences enter to complicate the process and render more imperative the exercise of the greatest care and skill.

From the crusher the flaked meats drop into a conveyor which delivers them to the heaters, or cookers.

CHAPTER V.

COTTONSEED (Continued).

Cooking Meats. Cake-forming. Winkle's Modification of the Extraction Process. Hydraulic Press. Pressing. Hydraulic Pump. Accumulators. Automatic Change-valve. Application of Pressure to Hydraulic Presses. Relation of Heaters and Presses. Increasing the Yield of Oil. Use of Press-cloth.

Cooking Meats.—If the efficient performance of one step in the preparation of cottonseed-oil is more important than another, or if there is one in which the character of the seed has a greater determining influence upon the yield and quality of the product, it is cooking. As we progress in our knowledge of the preparation of cottonseed-oil and its associated product, cottonseed-meal, the significance of the careful performance of each step becomes more apparent. The purpose of cooking is to modify the consistency of the meats through heat that the maximum yield of oil may be expressed. The heat of the cooker expands the oil in the meats and increases its fluidity, coagulates the albumen, expels the excess of natural moisture by evaporation and reduces the meats to the consistency desired for the best results in the hydraulic press.

The heaters, types of which are shown in Figs. 30, 31, and 32, are essentially circular steam-jacket pans of one-piece cast iron or riveted sheet steel surmounted by chutes which deliver the meats from the crusher, and provided with outlets, which may be either on the bottom or side, for the discharge of the cooked meats to the conveyor, which in turn delivers them to a sub-heater placed beneath the cooking-heaters.

Mechanical agitation of the meats during heating is effected by means of horizontal blades attached to a vertical shaft, which may be driven from either above (Fig. 30) or below (Figs. 31 and 32).

The heaters, as a rule, are provided with a live-steam coil, for the direct injection of steam should occasion require the addition of moisture, and detachable covers. The heaters are supported by a heavy iron frame, which also carries the driving-gear, and are arranged in batteries of seldom less than two, and as a rule three, and sometimes four or more in number. The heaters, steam-jacketed on both sides and bottom, are from 52 to 72 inches in

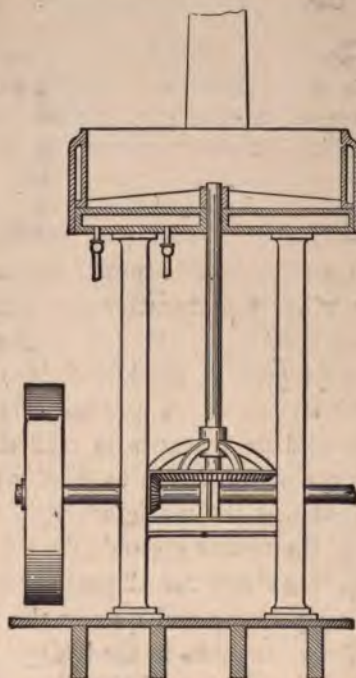


FIG. 29.—Cross-section of Heater with Bottom Drive.

diameter and from 14 to 18 inches deep. They differ in size and number according to the capacity of the mill. The steam-jackets are provided with pressure-gauges. Steam-traps for the automatic removal of water of condensation are essential, otherwise water may accumulate, and while the pressure indicated under such conditions may be satisfactory, the temperature is entirely inadequate to effect the evaporation required.

It is in the cooking of the meats that the automatic mechanism,

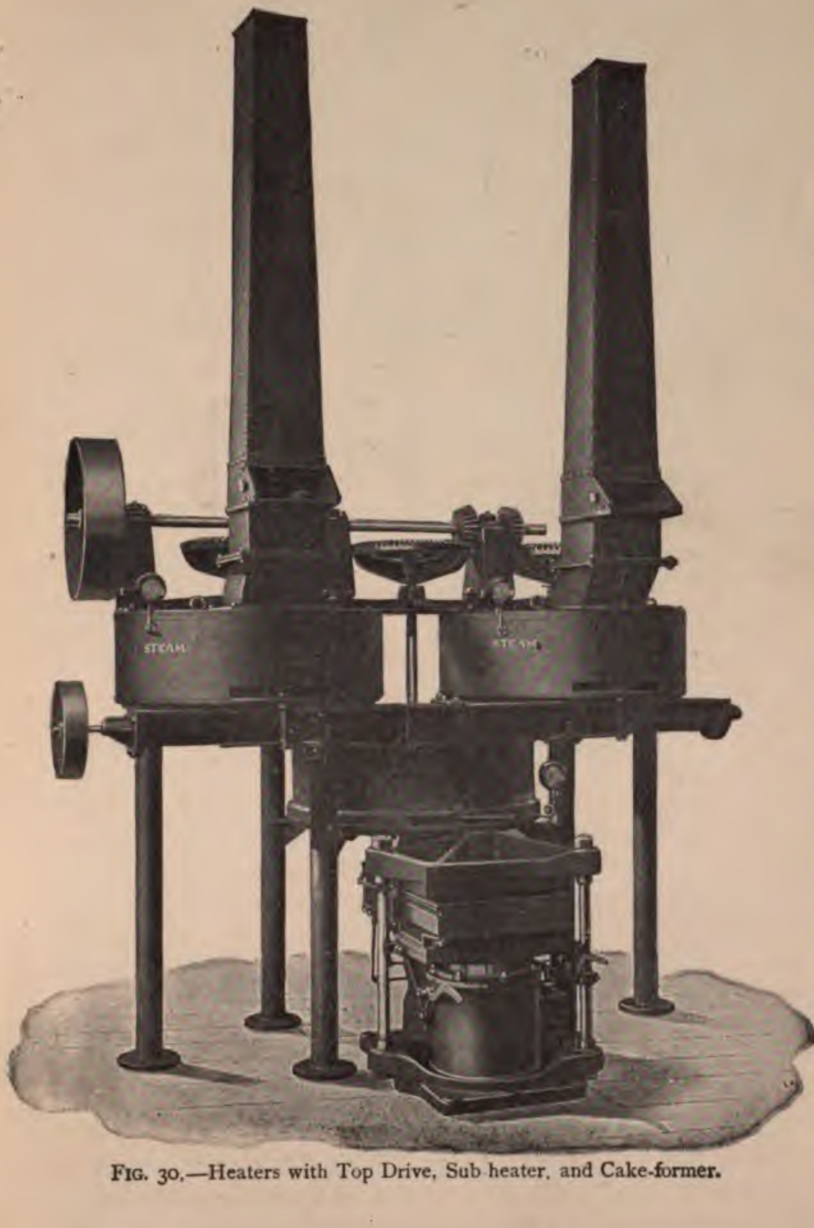


FIG. 30.—Heaters with Top Drive, Sub-heater, and Cake-former.

which has been so far followed, is first supplemented by the judgment of the attendant, and it is upon his knowledge and skill that the success of the operation depends. With a battery of two heaters the procedure of charging the heaters, cooking and discharging the cooked meats is as follows:

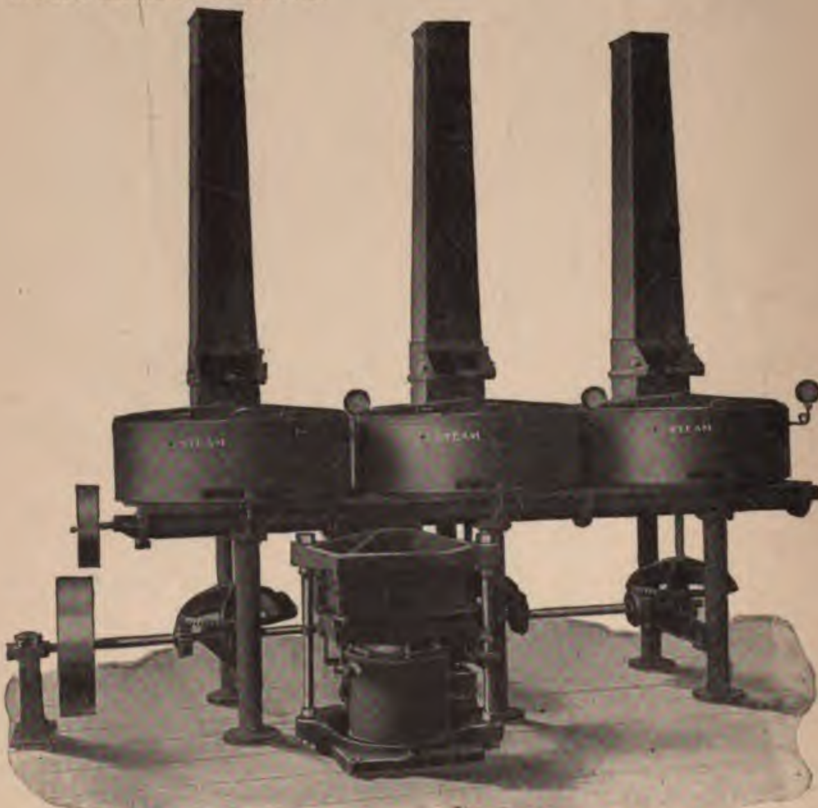


FIG. 31.—Heaters with Bottom Drive and Cake-former.

The heaters are charged in succession, with the feed so regulated that when the second heater is filled, the contents of the first heater have been cooked and ready to be discharged into the sub-heater. Cooking now proceeds in the second heater while the first heater is being filled, and so on. With three or more cooking-heaters in the series the same system of operation prevails. The length of time required for proper cooking depends upon the dry-

ness of the meats, varying from 15 minutes, with meats very dry, to 45 minutes, with green or damp meats. The steam-pressure in the jackets will depend upon the same conditions with regard to seed and upon the length of time in which it is desired to complete the operation, and may vary from 40 to 100 pounds. With very dry seed it is necessary to add moisture to the meats to assist in cooking. The direct injection of steam alone usually suffices for this purpose. Green seed as a rule cooks very easily and frequently with such rapid evaporation of moisture that it is necessary to raise the cover of the cooker to allow the steam to escape before the meats are brought to the proper consistency for pressing. Heating should not be too rapid to secure the best results, viz., bright, compact cake and light-colored oil. If cooked too much the cake is brittle; if cooked too little whereby an undue amount of moisture is retained, the meats ooze out of the press-box, injuring the press-cloth and producing a "leathery" cake. Hasty cooking tends to make the oil too red and the cake too hard.

The tendency of the flaky meats to agglomerate in small lumps or "water-balls" under the action of the stirrers, may be corrected by subjecting the crushed meats to the action of a beater, whereby they are reduced to a meal. Heat penetrates the interior of the "ball" with difficulty, with the result that the action on the press-cloth of meats containing them is the same as that of under-cooked meats.

With seed of uniform quality, which uniformity may frequently be maintained for periods of several days or a week or longer, the steam-pressure may be kept constant and the time of cooking varied to suit conditions of the meats; or the time of cooking may be kept constant and the steam-pressure varied according to the moisture-content of the meats. The temperature of cooking does not, as a rule, exceed 220° Fahr.

Owing to the varying character of cottonseed with respect to its moisture-content, a system of the strictest regularity at the cookers, with respect to time allowed for each batch of meats, steam-pressure, etc., becomes impossible. The entire responsibility of successful operation rests upon the "cook." His judgment and experience must determine the nature of the treatment followed, and with him

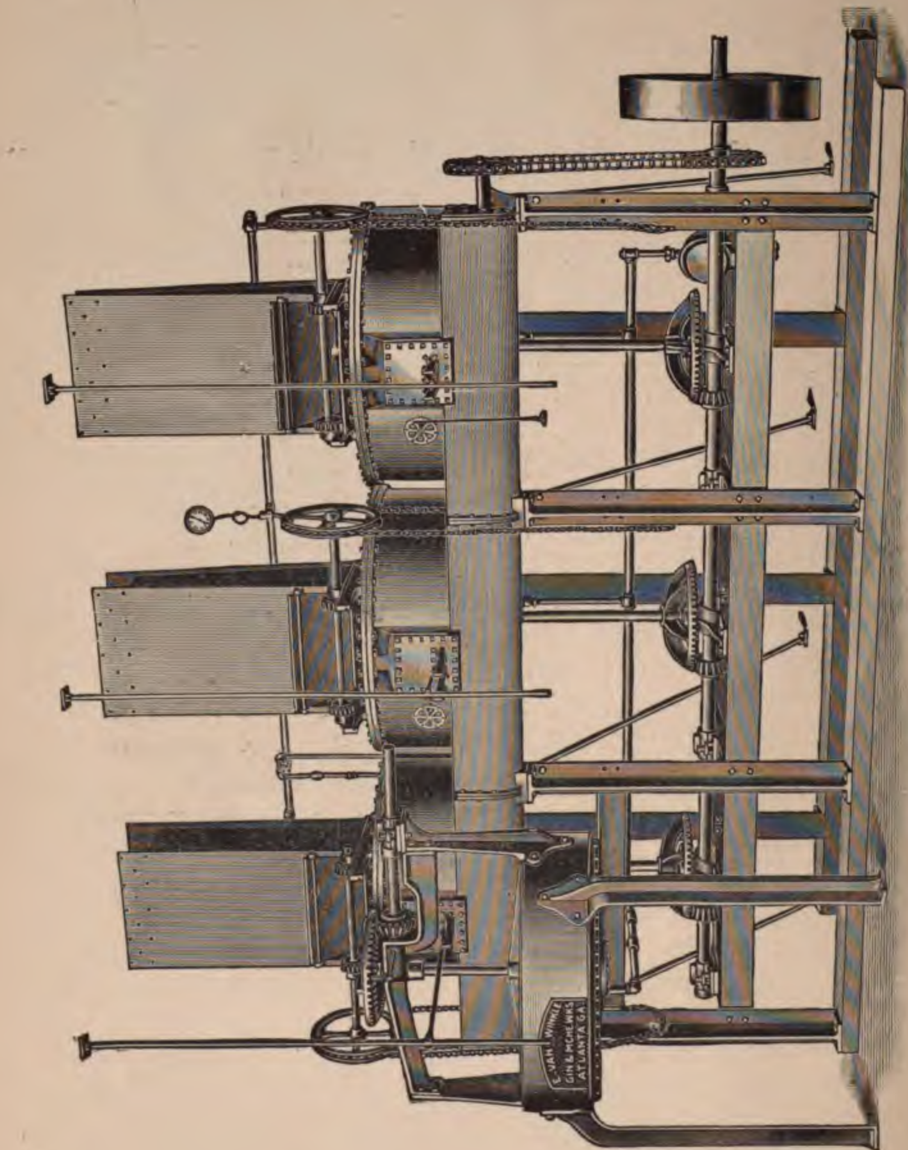


FIG. 32.—Heaters with Bottom Drive and Sub-heater.

must reside the responsibility for the successful results of his work. The right temperature, uniform distribution of the heat, and a thor-

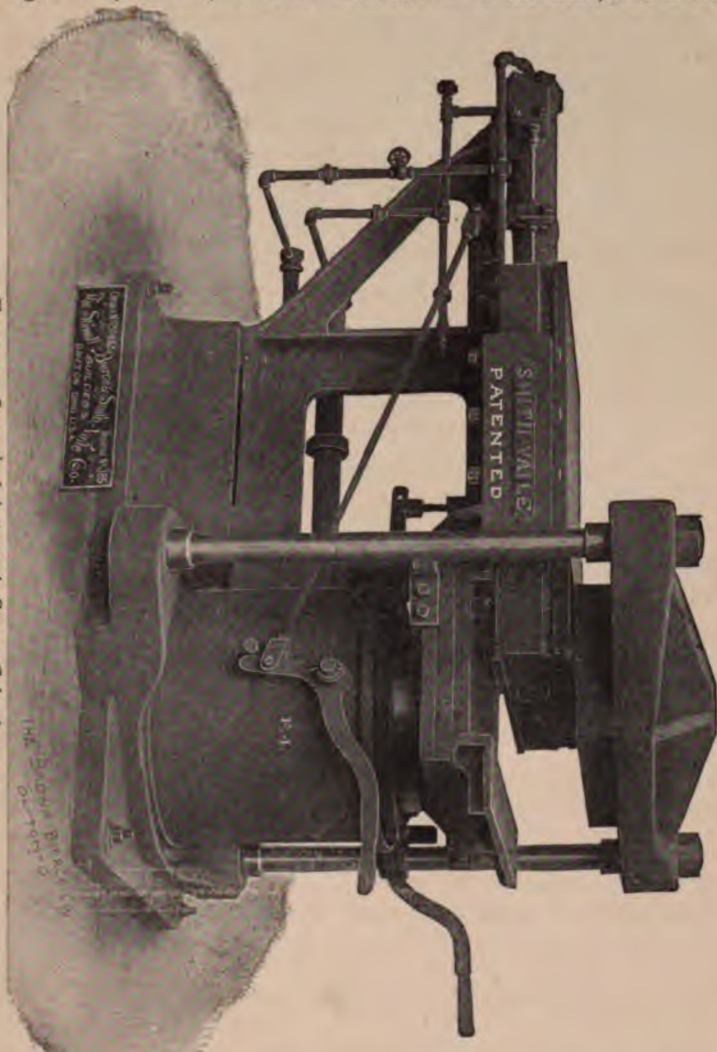


FIG. 33.—Improved Automatic Steam Cake-former

oughly homogeneous mixture of the mass of meats are prime essentials of proper cooking.

The sub-heater is similar in construction and manipulation to the cooking-heaters. It is placed below the bottom level of the

cooking-heaters and receives the cooked meats from them by conveyor. Formerly the cooked meats were delivered directly to the cake-former but not with entirely satisfactory results, as the last portion of the charge remaining in the cooker was often cooked too much. By the use of the sub-heater, which is now general, the entire charge when cooked can be delivered by conveyor to the sub-heater and there retained without decrease of temperature until all is put through the cake-former. When the process is completed in the cooking-heater and the meats delivered to the sub-heater, it is essential that proper thermal conditions be maintained there.

Cake-forming.—The cake-former, shown in its relative position to the heaters in Figs. 30, 31, and 32, is illustrated separately in Fig. 33. Its object is to shape or form the cooked meats into compressed cakes of uniform size and weight before subjecting them to pressure. In the steam-former shown in Figs. 30 and 33, the ram is 18 inches in diameter and is provided with an automatic cushioning device for the drop or return stroke. The carriage runs beneath the outlet of the sub-heater, from which is delivered a uniform quantity of cooked meats. On the top of the ram is laid the press-cloth, onto which the carriage discharges its quantum of cooked meats. Under steam-pressure the ram ascends, subjecting the whole to the desired pressure. The press-cloth is then folded over the cake, which is carried on a tray or plate to the press and inserted in an empty compartment. The former is ample for four presses. Great care should be taken that the cakes be made uniform in thickness and density, and be properly wrapped, so that pressure is exerted uniformly, otherwise loss is suffered through injury to press-cloths.

There are various types of formers. The ram may be operated by direct steam-pressure as described, hydraulic pressure, compressed air, or driven by belt.

Transferring cooked meats from the sub-heater to the former is likewise effected in a number of ways.

Van Winkle's Modification of the Extraction Process.—It is naturally to be desired that the maximum yield of oil be obtained, and many patents for processes looking to a closer approximation of the theoretical yield have been recorded. The tendency of all manufac-

turing is toward simplicity of operation consistent with economy. Closer approximations to theoretical yield from raw material in any industry may involve greater expense, either in direct outlay or in inconvenience or added complexity of operation, than there is economy secured. Experience with new ideas in the varying conditions of practical work can alone determine their value.

Van Winkle's patent relates to an improvement in the process of extracting oil from cottonseed, whereby the yield of oil is claimed to be increased and the operation rendered cheaper, simpler, and more effective. In Fig. 34 is represented diagrammatically an apparatus for carrying out the process.

In this apparatus, *a* represents the huller, and *b* the conveyor, which delivers the broken seed from the huller to the elevator *c*, by which elevator they are delivered to the separator *d*, the hulls being discharged at the end of the machine, while the meats fall down into the conveyor *e*, from whence they pass through the chute *f* to the elevator *g*. The elevator *g* delivers them to the crushing-rolls *m*. This conveyor *h* is surrounded by a steam-jacket *i*, into which steam is delivered through a pipe *j*, the purpose of this steam-jacket being to heat the meats during their passage through the conveyor *h*. A steam-pipe *k*, provided with a valve *l*, connects the steam-pipe *j* with the conveyor *h*. This is for the purpose of moistening the meats if moisture is necessary. This conveyor *h*, with its steam-jacket and steam-pipes connected to the conveyor and jacket, is what may be called a "tempering device," whereby the meats are prepared for the crushing operation. If the cottonseed is fresh, no moisture is needed. If, however, it is old and dry the subsequent operation will be much facilitated by moistening it before it is crushed. If the seed is very fresh, the meats are soft and sticky, containing in some instances too much moisture. This objection is also overcome by means of the tempering device, some of the surplus moisture being dried out and the meats thereby brought to the right consistency for the crushing. The meats after being crushed by the train of crushing-rolls *m* fall into a conveyor *n*, which delivers them into an elevator *o*, which delivers them in turn into a conveyor *p*, located above the cooker *q*. This cooker is supplied with steam by means of the pipe *r*, which is connected with

the steam-pipe *j*. After the mass has been thoroughly cooked it is put into the press *s* and the oil expressed in the usual way.

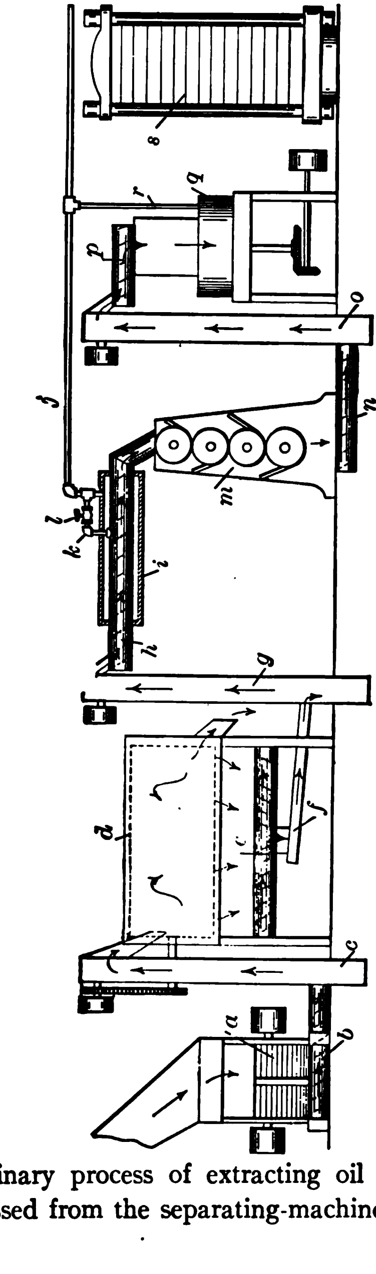


FIG. 34.—Diagram showing Van Winkle's Process of Cottonseed-oil Extraction.

In the ordinary process of extracting oil from cottonseed the kernels are passed from the separating-machine direct to the crush-

ing-rolls, where they are crushed cold. The crushed mass is then passed into a steam heater or cooker and then to the press, where the oil is extracted by pressure. The patentee has found by actual trial, however, that the yield of oil can be considerably increased if the cottonseed are hulled and if the meats are crushed under the influence of heat, either by having the rolls themselves heated or by heating the meats before they are delivered to the rolls, or both. This is the most important feature of Van Winkle's process, that the meats should be crushed hot, either with or without the addition of moisture, before the crushing operation, as the condition of the meats requires.

The use of crushing-rollers, as is well known, is to break up the oil-cells and disintegrate the fibrous matter preparatory to the cooking of the crushed mass. By Van Winkle's process, however, the disintegration of the oil-cells and fibrous matter is far more completely done by reason of the fact that the crushing is done under the influence of heat, and by actual experiment Van Winkle found that it is possible to use a much lower degree of steam-pressure in the cooker or digester *q* and a much lower degree of pressure in the press *s*; also, that the amount of press-cloth required in said press is much less than it was under the old conditions, and that the oil-cake itself is more attractive and regular in appearance, being free from the greenish spots which often occur from balling in the heaters or cookers. Van Winkle found by actual trial that these valuable results are secured by properly tempering the meats before the crushing operation. By "tempering" he means subjecting the meats, either with or without the addition of moisture (which moisture may be either in the form of steam or water), to the action of heat before said meats are delivered to the crushing-rolls. Van Winkle found by experiment that the efficiency of the process increases from the beginning until the time when the rolls are well heated up, as of course they will become heated by contact with the heated meats. An hour after the use of the apparatus is begun, it is found that the yield of oil is sensibly increased. Winkle therefore prefers to heat the rollers in the beginning of the operation, although after they have once been heated up there is no necessity of continuing to heat them.

One of the serious objections to the ordinary process of extracting oil from cottonseed is that unless the seed is fresh moisture must be added to it to have it cooked properly. This is generally done in the cooker or digester *q*; but the addition of moisture to the crushed mass in the cooker itself has serious objections. Just as would happen if water were poured into flour, the crushed mass when subjected to the action of moisture forms balls oftentimes of considerable size, and if one of these balls were broken it would be found that while the exterior was properly cooked the interior would be practically uncooked. The result would be that when one of these balls got into the press it would tear the press-cloth, thus materially increasing the expense, and would make a greenish spot in the pressed cake. Van Winkle overcomes this objection by introducing moisture into the meats before they are crushed, so that during the crushing operation the moisture is thoroughly and intimately mixed with the crushed mass, the result being that in the subsequent cooking there is practically no formation of balls. As said before, some varieties of seed when fresh contain enough moisture, and in this case none need be added. If, however, the seed is old and dry, the operation is much facilitated by adding a small amount of moisture to the meats before they are crushed.

Hydraulic Press.—The apparatus required for pressing oil from the cake comprises the hydraulic press (Figs. 35, 36), low- and high-pressure pumps (Figs. 38, 39), and accumulators (Fig. 40), which with their appurtenances constitute in their construction and operation the most delicate and complex part of the equipment of a crude cottonseed-oil mill. The operation of the hydraulic press is based upon the principle of hydrostatics that a pressure exerted upon any part of the surface of a liquid is transmitted undiminished to all parts of the mass and in all directions. Thus, if we have a cylinder filled with water, in one end of which works a plunger 1 inch square and in the other end of which works a plunger 12 inches square, this pressure will be transmitted undiminished by the water and will exert a total pressure of $1 \times 12 \times 12$, or 144 pounds. The essentials of a hydraulic press are, therefore, a small cylinder containing a plunger to which pressure is applied, connected by a pipe

with a large cylinder containing a plunger which transmits the multiplied pressure to the material to be pressed.

The modern plate-press, shown in front elevation with empty compartments in Fig. 35, and in side view in Fig. 36, has almost entirely superseded the old-style box-press, owing to its greater capacity, compactness, and economy both in operation and use of mats and bags. With the box-press the cooked meats were placed in woollen bags and these spread out and equallized in thickness on "mats." These mats were closely woven from horsehair and covered with a leather back, the whole very much resembling a book which opens at the end. The mat was closed upon the woollen bag of meal, the open end of the bag being folded over itself next to the hinge of the mat. It was then placed in a compartment or box of the press. When all the boxes, usually six in number, were filled, pressure was applied. With the present plate-press, twelve to fifteen cakes occupy the place which, in the old box-press, was filled with six cakes. A very considerable increase in capacity with the same pressure and apparatus has thus been made possible by the substitution of plates (Fig. 37) for bags and mats.

The capacity of a press depends on the weight and number of cakes. A press with a ram 16 inches in diameter contains from 12 to 16 plates. Smaller presses with a 12-inch ram contain from 7 to 12 plates of proportionately smaller area. The average size of cake made with the larger press is 14×32 inches, which, to secure the best results, should not weigh more than 12 pounds, although with well-cooked meats a cake weighing $13\frac{1}{2}$ pounds may be made.

Pressing.—The cakes of cooked meats, wrapped in camel's-hair cloth and subjected to a pressure in the former just below what is necessary to bring the first running of oil, are carried by hand on a steel plate or tray, and inserted into the empty compartments of the press until the latter is filled. The system of applying pressure to the press depends upon the number of presses, and in any case the application is made in two successive stages. In the first stage a comparatively rapid movement of the ram is made to bring the plates together; to take up the "slack" of the press, as it is called, and to allow the cloth to "set," or conform itself to the shape the cake is destined to assume without injury to the cloth.

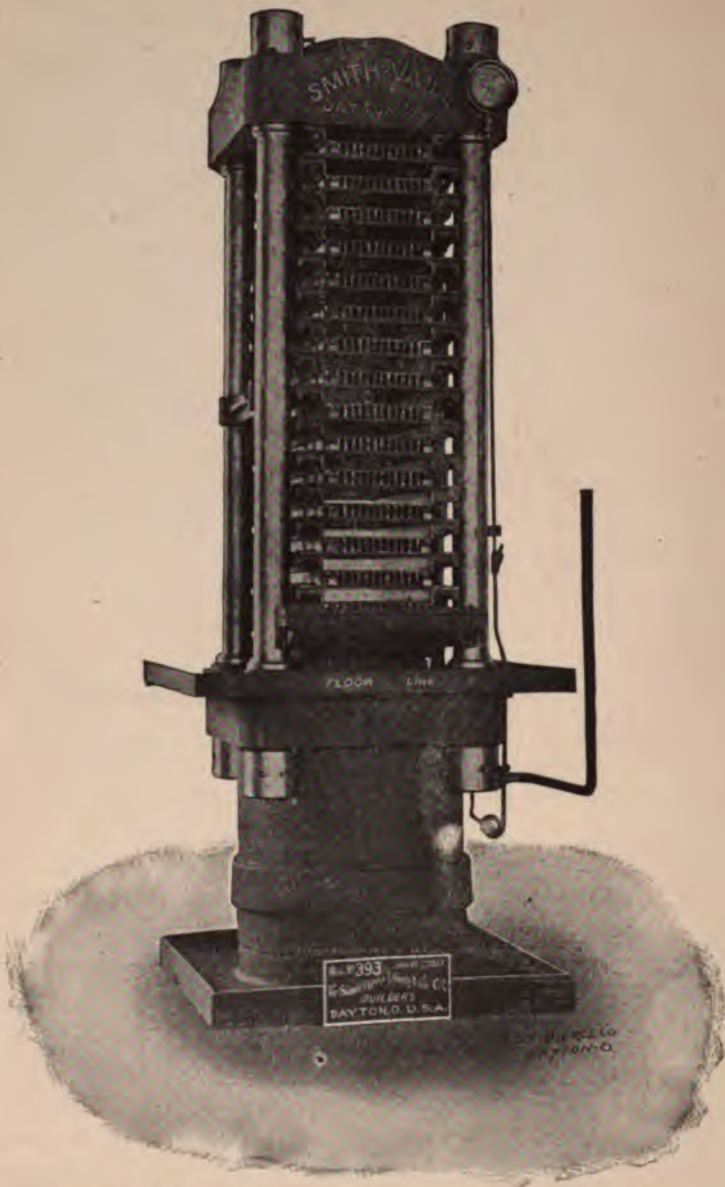


FIG. 35.—Hydraulic Press without Change-valve—Front Elevation.

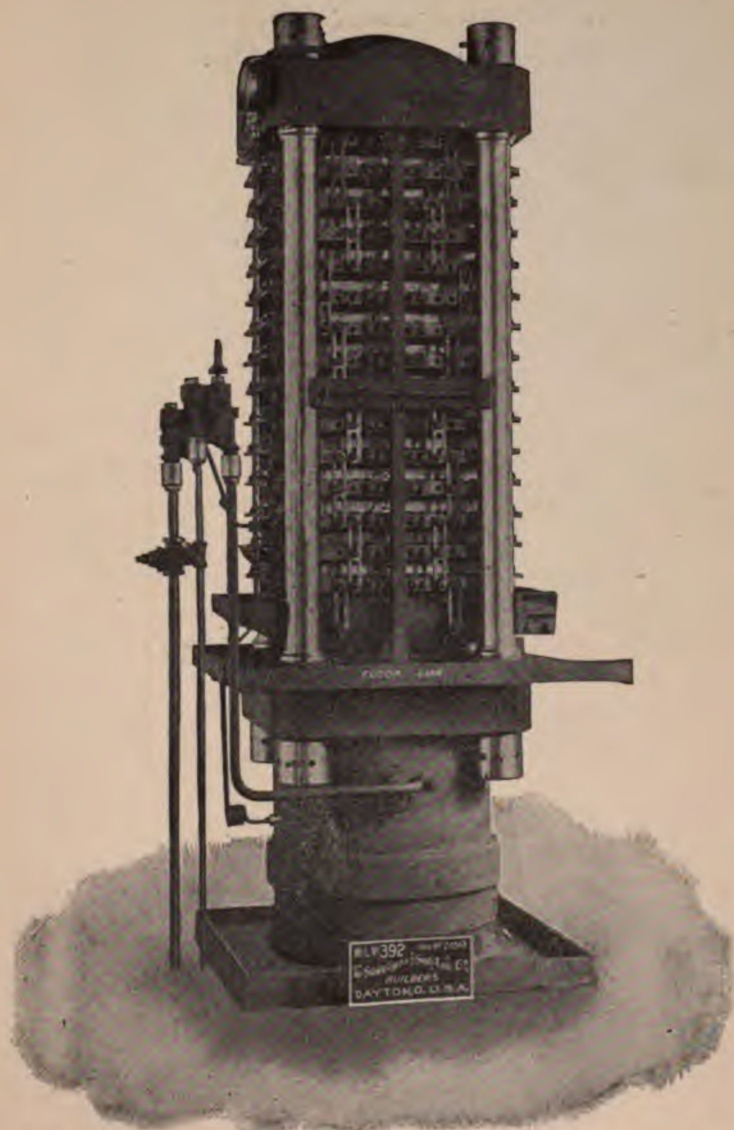


FIG. 36.—Hydraulic Press with Automatic Change-valve—Side Elevation.

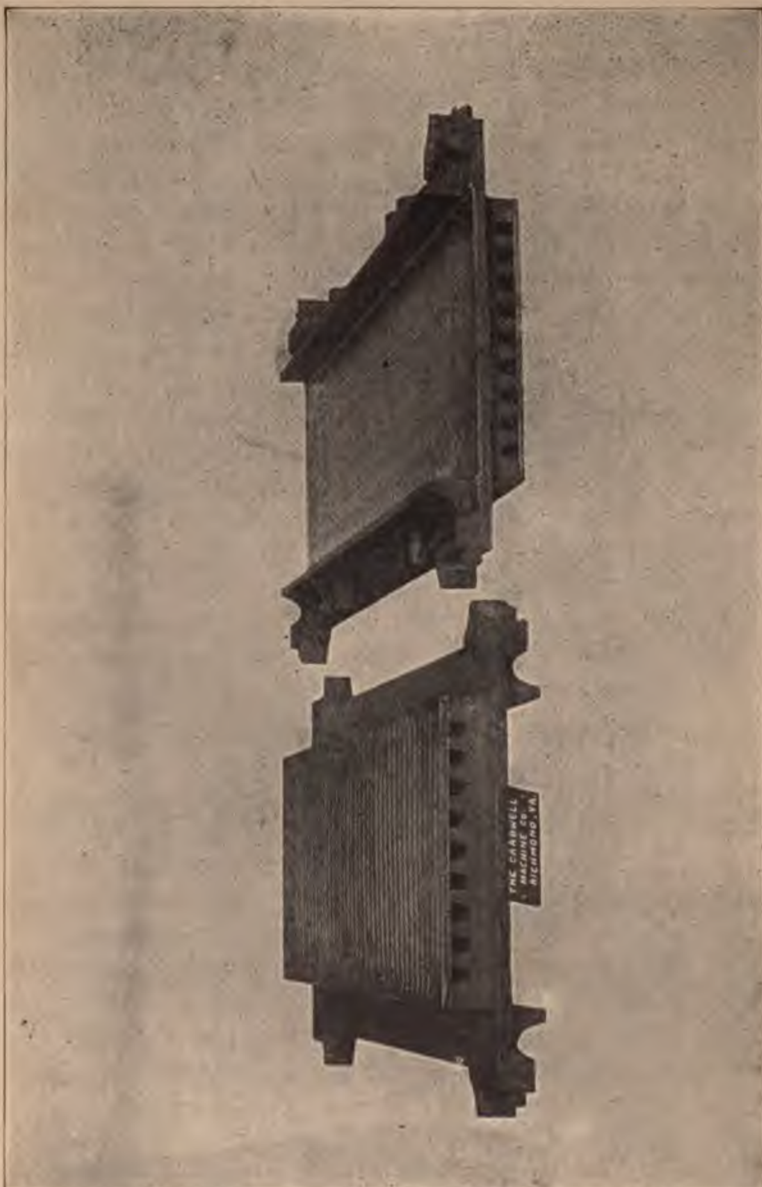


FIG. 37.—Cast-steel Press-plate.

The pressure applied to the ram by the hydraulic pump in the first stage, as a rule, does not exceed 400 pounds per square inch. In the second stage a much slower movement of the ram is made, during which the greater part of the oil is expressed by allowing the plates to come together and the compressed cake to drain. During the first stage two-thirds of the travel of the ram is made and the oil started. During the second stage the pressure is gradually applied to the maximum, the cake assumes its final density, and the last traces of oil, possible under the pressure given and the time allowed, separate. During the second stage the maximum pressure applied to the ram, as a rule, does not exceed 4000 pounds per square inch. With a ram 16 inches in diameter, which is the average size for the modern press, its equivalent area of 201 square inches will exert a total maximum pressure of 804,000 pounds upon the cake. With a cake 14×32, or 448 square inches, the pressure per square inch will be nearly 1800 pounds.

Hydraulic Pump.—Pressure is applied by means of a hydraulic pump. With an equipment of but two presses, one pump of a special construction, a type of which is shown in Fig. 39, is used for the application of both low and high pressure. This pump is provided with an automatic regulating-valve shown at the right in Fig. 39, and attached to the steam-pipe. It admits sufficient steam to operate the pump at uniform speed. As the pressure rises it automatically admits more steam, until the maximum pressure for which it is set is reached; then it automatically closes and stops the pump. To the left (Fig. 39), and attached to the hydraulic cylinders of the pump, is the safety-valve which limits the maximum pressure. With more than two presses the work is divided between two pumps, one for the low pressure and the other for the high pressure. A type of low-pressure pump is shown in Fig. 38. With more than four presses increased flexibility is given to the hydraulic system by the addition of an accumulator (Fig. 40).

Accumulator.—The accumulator is a device for equallizing pressure, or for the accumulation of energy for intermittent use. It consists essentially of a vertical cylinder resting on a firm base and having a plunger working through a stuffing-box at the top. This plunger has at its upper end a yoke which carries by means of

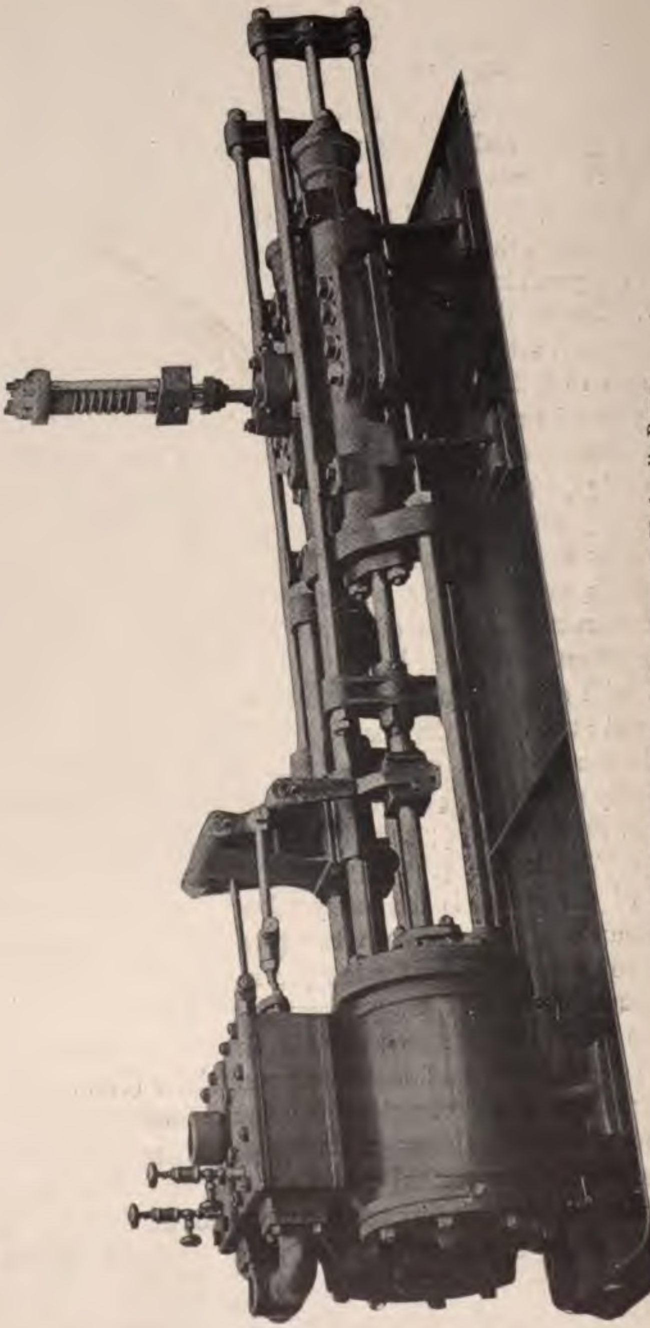


FIG. 38.—8″ × 2½″ × 10″ Low-pressure Hydraulic Pump.

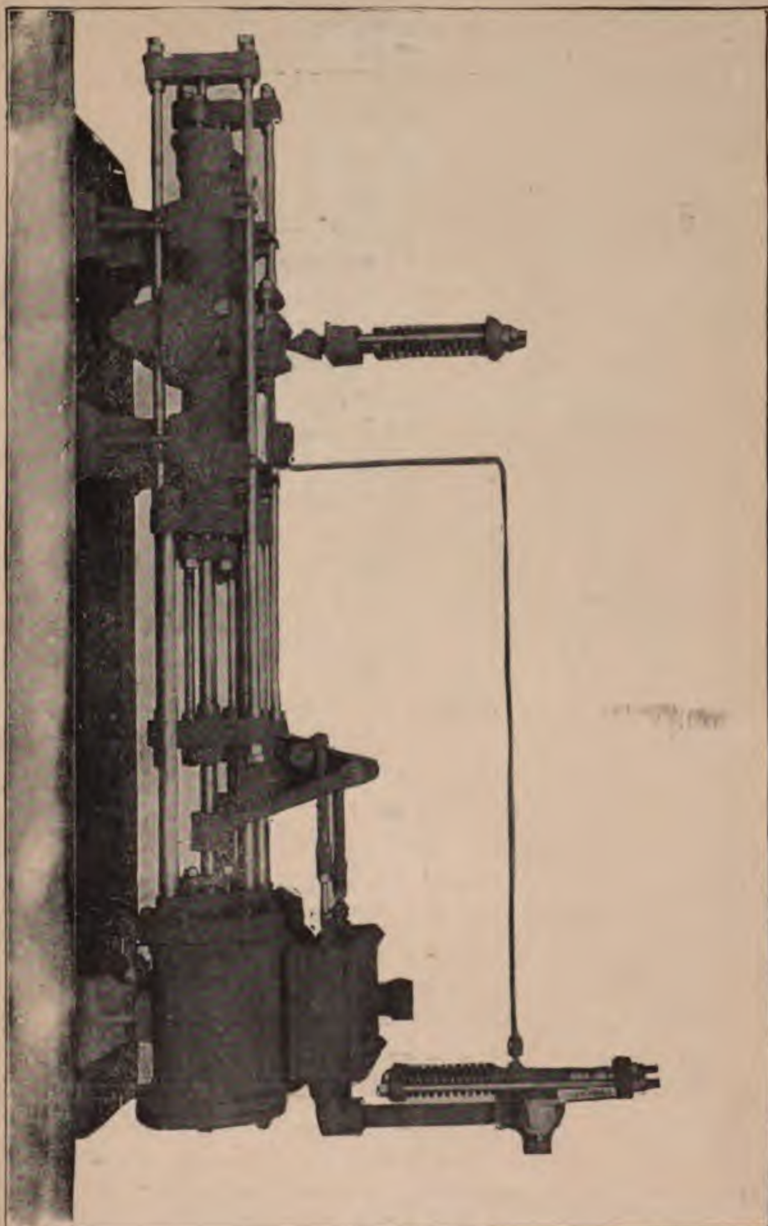


FIG. 39.—8″ × 1″ × 10″ High-pressure Hydraulic Pump.

suspension rods a heavy weight of cast iron. A pump forces water or oil into the cylinder at a pressure sufficient to lift the weighted

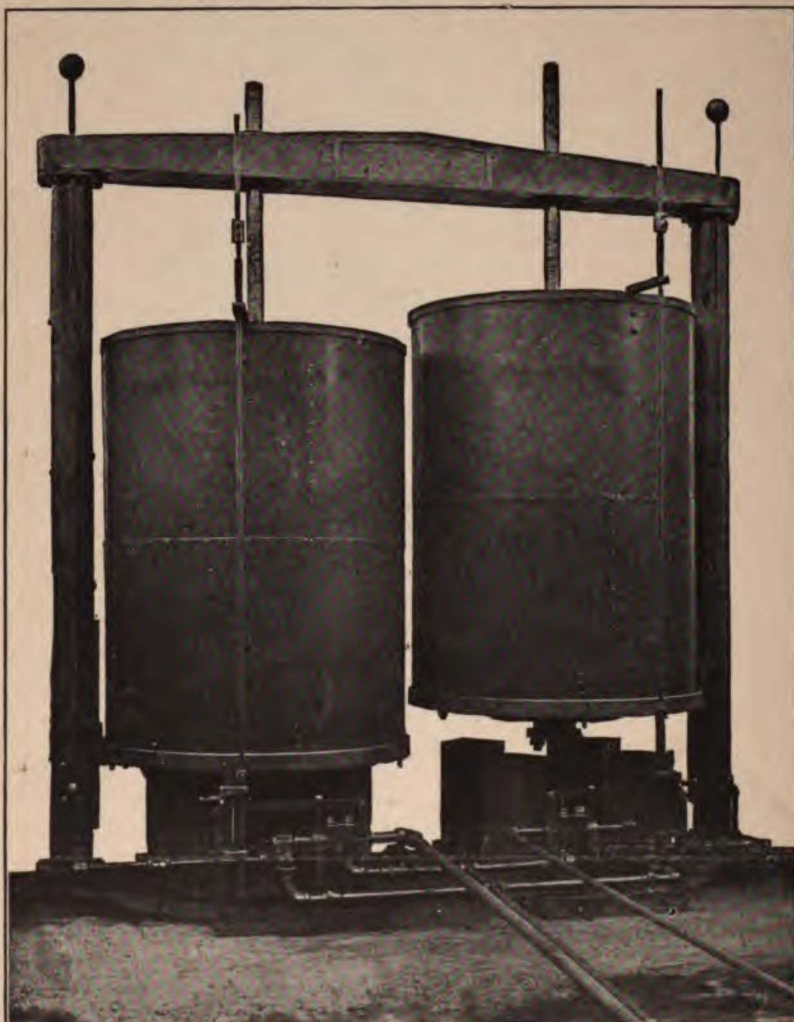


FIG. 40.—Accumulator.

plunger to the top of the cylinder, where it automatically stops. In this position the cylinder is filled with a column of liquid which supports the weighted plunger on its top. As water or oil is drawn

off from the cylinder to supply the press the weighted plunger descends, always keeping a pressure on the top of the column of liquid equal to the combined weight of the plunger and its load. As soon as the plunger descends the pump resumes work and raises it again. By this combination of operations, water-pressure is 'always kept constant for supplying the presses. The term "dead weight" is commonly applied to this type of accumulator. In the 'pneumatic" accumulator the pressure of compressed air replaces the weight of supported metal. Air is compressed by pumping water or oil into a closed vessel containing it. Its operation is the same as the "dead-weight" accumulator.

The accumulator may be used in connection with either the low-pressure or the high-pressure pump, but more commonly with the former. With the use of the improved "change" valves of automatic type, whereby pressure is transferred from the low-pressure pump to the high-pressure pump without injury resulting from sudden application of increased pressure, the necessity of the accumulator is much lessened.

The fluid commonly used in both the accumulator and presses is cottonseed-oil, preferably refined. To avoid clogging and abrasion, the oil should be kept free from foreign matter of every description. Oil in prolonged use for this purpose tends to thicken and should be replaced with fresh oil when for any reason it becomes unsuitable.

Automatic Change-valve.—The regulation of the pressure applied to the press by the pump is effected by means of the "change" valve, of which there are various forms. In the form shown in detail in Fig. 41 the adjustment is automatic. It gives to the ram of the press a very high speed up to the point where the pressure is sufficient to take up the "slack" of the press and to start the oil from the meats. From that point it limits the speed so as to give a very slow continuous movement. It not only regulates the action of the press in this manner but also saves power by using high-pressure oil only after the low pressure has done its work and carried the press to about its limit.

The action of the valve is as follows: When a press is sent up this valve remains open and allows a free passage for the oil until

the slack is taken up and pressure begins to be applied to the cake. This pressure, when sufficient, by acting on the $\frac{5}{8}$-inch piston lifts the lever arm carrying the weight. This forces a $\frac{1}{2}$-inch piston, situated beyond the pivot, upon its seat through which the oil has been passing. Immediately the speed of the press is slackened, but not stopped entirely, as a groove in the end of the $\frac{1}{2}$-inch piston allows a limited amount of oil still to pass. By reversing the piston which has a different sized groove at either end, and by shifting the weight, absolute control of speed and time of action is obtained. The lever falls and the valve opens automatically when the next press is sent up.

Application of Pressure to Hydraulic Presses.—In an excellent practical paper on the application of pressure to the hydraulic press, read by J. C. Weaver before the Texas Cottonseed Crushers' Association at Fort Worth, Texas, July, 1900, the following valuable points on this important part of the oil-miller's work were brought out:

"In the application of pressure to hydraulic presses, as applied in cottonseed-oil mill-work, there are several points to be considered: a rapid movement of the ram of the presses, at the start, in order to take up "the slack," that is, to bring the plates together; a stoppage of this movement at the proper pressure in order to allow the cloth to set without damage to it; then a slow movement of the ram to allow the plates or boxes to close only as the oil can be drained therefrom, thereby again reducing the liability to injure press-cloth by the too rapid pressure being exerted for the proper discharge of the oil through the openings provided therefor. A rapid movement of the presses in the beginning enables a longer drainage to be gotten, as the time necessary for closing the press-plates and bringing them to the point of extraction of the oil is greatly reduced.

"On the other hand, a shorter time for the total operation of the presses to the point of actual work will result in the increase of the capacity of the mill, with attending good results, not only in the increase of drainage time, but in the reduction of the labor account per ton of seed worked. The old method of applying pressure by the means of power pumps, without any variation of capacity or speeds, seems to have been relegated to the past, and properly so. In mills of capacities of 60 tons and over, the accepted and desired

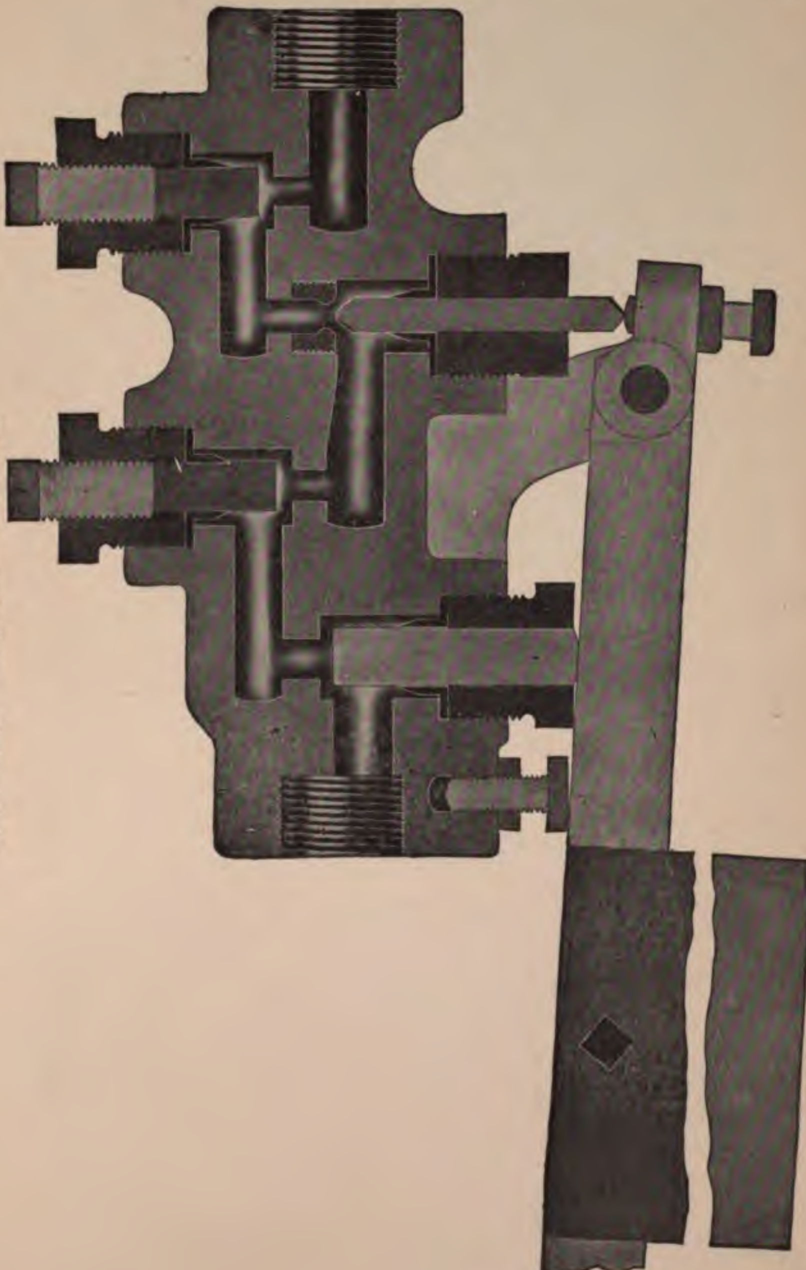


FIG. 41.—Automatic Change- (Choker-) Valve.

method, at this time, is the application of a high and low pressure either by means of belt-driven or steam-actuated pumps. That the high- and low-pressure application is the correct theory, from a standpoint of economy and proper mechanical principles, there can be no doubt, but the best and most satisfactory means of arriving at the result is the point to be considered. The power pump, belt-driven, in connection with the weighted accumulator has been used, and with good results. The weighted accumulator, however, is a cumbersome affair, taking up considerable space, and being necessarily more expensive than some other methods. The power pump is a complicated affair, on account of its numerous working parts, consisting of working-barrels and pistons or plungers, and their packing, cross-heads, eccentrics, cranks, or walking-beams, valves, etc. The necessity of operating the presses by means of change-valves made as a part of the pump proper, requiring the operator to go to the pump at each time of turning on the press, is also an objection. This class of pump being compelled from necessity to continue in constant operation, with the attending wear and tear on its working parts, its packing, etc., makes it especially objectionable. In the event of any necessity for shutting down the mill from any cause, the pressure on the presses ceases and the presses become entirely inoperative. By the use of high- and low-pressure independent pumps, operated by direct steam-pressure automatically handled or controlled by the change-valves, located at the most convenient place near the presses, a much simpler arrangement is obtained.

"By means of a single-handed valve, operating the change-valve proper, in connection with the valve for automatically controlling the high- and low-pressure pumps, and this valve located at the presses, no time is lost. Immediately on the opening of this change-valve, the expansion of the compressed air, with which the accumulator is charged to a pressure of 400 to 600 pounds per square inch, forces the oil in front of it, and filling the cylinders of the presses and the pipes leading thereto, rapidly closes up the slack of the boxes, preparatory to getting the press down to actual work, and does this with perfect freedom from the pulsations and thrust of the pump when working direct, having when the plates are brought

to a close much the same effect on the cloth as applying a steady constant strain on a string or rope, as compared to continuous jerks. The low-pressure pump acts only on the accumulator and not directly on the press-rams, except through the medium of the accumulator in which the pressure is stored. The automatic valve attached directly to the press, and being part of the change-valve, permits the low pressure from the accumulator to operate directly on the ram until the maximum pressure for which it is intended is reached. By the operation of this valve the low pressure is shut off and the high pressure started, when the maximum pressure for which the low pressure is set has been reached. The slack of the press having been taken up and the material in the box set, what is now needed is a steady pressure and freedom from pulsation, closing the boxes as oil is discharged from them. This movement is controlled by valves having small openings, known as chokers.

"At the time of the starting of the high-pressure pump, the cloth has adjusted itself to its boxes, the oil has been started, and two-thirds of the travel of the ram has been made, and the high-pressure pump, acting independently of the low-pressure, as well as the accumulator, maintains a constant pressure in the header, which is steady and reliable. Automatically operated pressure regulators close the pump down when the maximum pressure is reached, or throttles to such an extent as to allow only such a movement as may be required to overcome the drainage of the oil from the material in the boxes and maintain pressure for which they are set.

"Safety-valves properly set a little in advance of the pressure required, both on the accumulator and the high-pressure pumps, overcome any liability for damage, should any of the parts fail to operate properly.

"The steam-driven pump operates only as the pressure is needed for each press independently, and while it is a well-known fact that the use of the steam directly applied, as in steam-pumps, is not economical as compared with its use through the medium of an engine using steam expansively; in the one the movements are constant, in the other they are intermittent. In the one the wear and tear is continuous, in the other it is reduced to only that time actually required for putting the pressure on the presses.

"The cost of maintaining the one as compared to the other is greatly in favor of that possessing the fewer parts and sustaining the least wear, and this is unquestionably the steam-driven pump. The independence of the steam-pumps from other machinery—the reduction of working parts, the rapid movement of the press—is due to the expansion of compressed air, preparatory to exerting the high pressure and the saving of time thereby. The ease in handling of press-cloth, that necessary and much-to-be-regretted evil genius of the oil-mill business, the reliability, and safety, all tend to preponderance in favor of that system in preference to any other, and the favor of which this has been received and used has proven that careful investigators have favored a practical method and been willing to test its merits."

Relation of Heaters and Presses.—With a capacity of 40 tons of seed per day the usual equipment is either two 52-inch heaters or one 72-inch heater for each pair of presses. Each 15-box press has a capacity of one-fourth ton of seed per pressing, which with 4 pressings per hour represents a maximum daily capacity of 24 tons. With fewer pressings per hour, the capacity per press per 24-hour day is correspondingly reduced. With three pressings per hour the daily capacity per press will be 18 tons.

The capacity of a 52-inch heater is about 500 pounds of cooked meats, which, with satisfactory steam-pressure and proper handling of the varying conditions attending the seed, can be cooked in thirty minutes. Thus a charge from a heater of this size will supply one press twice an hour, and two heaters cooking twice an hour will supply two presses eight times an hour. With the above equipment the supply for the presses per hour may be increased by either reducing the length of the cooking period or by increasing the charge at each cooking, which procedure is not to be recommended, as it is invariably accompanied by deterioration in the quality of the oil and cake. One 72-inch heater with good control of conditions will cook on an average 750 pounds of meats three times an hour, which is equivalent to a supply of meats nine times an hour for two presses.

A mill with an equipment of one 52-inch heater and one press will have a capacity of 10 to 20 tons of seed per day of 24 hours.

A two-press mill with either one 72-inch or two 52-inch heaters operated as described will have a daily capacity of 35 to 40 tons.

A three-press mill will work up 45 to 50 tons of seed a day. A four-press mill will work up 60 to 75 tons of seed a day.

Increasing the Yield of Oil.—The chief concern of the oil-miller is to obtain the maximum yield of crude oil from seed of given quantity and quality. This means the maximum percentage of crude oil in the storage-tanks and the minimum percentage of oil in the cake. These proportions are determined by the quality of the seed, which is the resultant of various conditions attending its growth and handling and the manner in which it is transformed into its products. The ingenuity of the chemist and engineer are directed most to the latter aspect of the industry. Among numerous suggestions for increasing the yield of oil is the invention of E. L. Johnson, of Memphis, Tenn., which consists, essentially, in mixing with a mass of cottonseed kernels a limited quantity of cottonseed-bran sufficient to make the mass porous, so that it shall yield up the oil more readily when pressed.

The descriptive character of Johnson's specification warrants its reproduction:

"In the manufacture of cottonseed-oil two general methods have been adopted. One is to hull the cottonseed, cook the kernels in a heater, draw off the heated mass into a former, where the mass is formed into cakes, and then subject these cakes to hydraulic pressure to press out the oil. This gives a good quality of oil, but leaves a considerable proportion of the oil in the cake. This is the method usually practised in this country. The other method, which is usually practised in England, is to roll the entire seed without separating the hull from the kernel and otherwise treat them as above stated. This gives an inferior quality of oil, because the presence of the hulls in the mass while it is being cooked is detrimental. The hulls are about half of the mass.

"I have discovered that by introducing a proper, limited proportion of the bran after the mass of kernels is cooked a larger yield of oil is secured without in any way diminishing the quality. In the first method described above it is a rare exception for the cake to

retain less than 8 per cent. of the oil, while it frequently runs as high as 15 to 18 per cent., and the general average by this process in mills in the United States at the present time is about 12½ per cent. I have never found more than 8 per cent. of oil left in the cake by my process. I have found it to run as low as 6.4 per cent., and believe that under more suitable conditions the test will not exceed more than 5 per cent. of oil left in the cake. In my process I hull the seed, separate the kernels as in the first process above stated, and then either add and mix in the cottonseed-bran before or after rolling and before cooking or add and mix in the bran in the heater when the meats are almost or quite cooked.

"The first of these processes is the more convenient and preferable when the quality of oil is not of so much importance, but the second, where the bran is added after the cooking is nearly or quite complete, gives a better quality of oil, for the coloring-matter in the cottonseed-bran is not then cooked or steamed out, nor is it liberated in the oil by pressure, as is very apt to be the case when the bran is added before cooking. When the kernels are cooked and the mass is about to be carried into the former, I add to the mass of kernels cottonseed-bran to the amount of about 10 per cent. by weight, and thoroughly mix the bran throughout the mass of kernels. This requires only a few moments, and before the kernels have time to produce any effect on the character of the oil I remove the mass from the heater and form it into cakes and press it, as before explained. I obtain thereby, with no more pressure than is usually applied, about 1½ per cent. more of oil, and the oil is of as good a quality as by the present process. Another advantage of my method, however, is that the bran gives a greater consistency to the cake than when only the kernels are used. The result is that when pressure is applied there is not the same strain upon the press-cloths and these are less rapidly destroyed. Furthermore, I am enabled to use higher pressure than economy of press-cloths at present admits of, and therefore obtain a larger increase in the oil than above stated.

"While I do not limit myself to any theory upon which to explain this operation, I believe the fact to be that the larger yield of oil is due to the increased porosity of the cake, which results from mixing

the bran with the kernels. In the second or English method above explained there is an increased porosity, but the bran itself absorbs and retains a considerable quantity of oil. With as much as 50 per cent. of bran present in the mass the absorption by the bran offsets the advantage which would otherwise arise from increased porosity in the mass; but in limiting the quantity of bran an increased yield s obtained, and by adding the bran just before the mass is removed from the heater to the former the deterioration of the oil is prevented.

"The quantity of cottonseed-bran which I must use runs from 2½ to 30 per cent. A larger quantity than 30 per cent. offsets the advantage of using bran by its own absorption of oil, and a smaller quantity than 2½ per cent. produces no appreciable increase in the yield of oil; but, while stating these limits within which my process is practicable, as a matter of fact I find it generally desirable to use about 10 per cent., as stated. I do not wish to limit myself to this proportion because the conditions existing at various seasons and at different points of manufacture—as, for instance, the relative price of oil and cake, the use to which the oil and cake are to be put, and the market demand—vary so much from time to time and place to place that it may be desirable to depart somewhat widely from the 10 per cent. which I prefer to use.

"Cottonseed-bran is the dark, solid portion of the hull of the cottonseed from which the short cotton fibre has been removed and is already upon the market as an article of commerce.

"I do not in those claims in which no percentage of cottonseed-bran is definitely stated limit myself to the preferred percentage of 10 per cent. thereof, as such percentage is not necessary, and my invention includes the use of the bran within the broader proportions hereinbefore stated."

Use of Press-cloth.—The cloths used for inclosing the cooked meats is of closely woven camels' hair. Their deterioration in use is no small item of expense in oil-mill operation. Their cost per ton of seed when the latter are treated under the best conditions should not exceed ten cents, but this figure is often doubled. The life of press-cloth is determined by the quality of the seed, the efficiency of cooking and the care used in applying pressure to the

press. Unevenly formed cakes are destructive of cloths, inasmuch as they cause the cake to "creep" in the press. The deleterious influence affecting the cloth is moisture. This factor comes into first consideration with the seed. Insufficiently cooked meats, whereby an undue amount of water is allowed to remain, are the chief source of injury to press-cloths. Prime cottonseed are least injurious. Off seed, such as half-ripe and unripe seed, that are abundant at the beginning of the oil-mill season, and frost-bitten and heated seed, work the greatest injury through carelessness in expelling the excessive moisture in the heaters. Under-cooked meats under application of pressure resist the separation of oil with such tenacity that the press-cloth yields instead. Water-balls, the formation of which is described in the section devoted to cooking meats, likewise rupture the cloth, through the resistance to pressure of the uncooked meats in their interior. Sudden application of pressure to the press by too rapidly running it up when filled, ruptures the cloth. By the use of automatic "change" valves, high pressure is applied at a point just below that at which the oil freely flows. It should be applied very slowly, for which automatic arrangement is made at the high-pressure pump, whereby at the time of change from low to high pressure steam is admitted very gradually to the pump; the limit to maximum pressure is also automatically controlled. With the improved devices for controlling the pressure, the loss of press-cloth continues almost entirely from improper treatment of the seed during heating.

The deterioration to which press-cloths or mats are subjected has directed much ingenuity to their improvement whereby they may be enabled better to withstand high pressure without rupture and without allowing meal to pass through the cloth. A recent patent by Werk * relating to improvements in press-cloth contains much information as to this important aspect of oil-mill work.

"In the manufacture of mats for oil-presses it is desirable to use animal hair, because such a cloth or mat gives a cleaner oil than mats made of fibrous or other materials, and this is due to the fact that the oil when expressed from the material goes through the cloth or mat and is not forced out at the sides, where there is nothing to

* R. F. Werk, New Orleans, La. Letters patent 758,572; April 26, 1904.

prevent the loose meats from washing out with the oil. Mats made of animal hair are also superior, owing to the absence of sediment

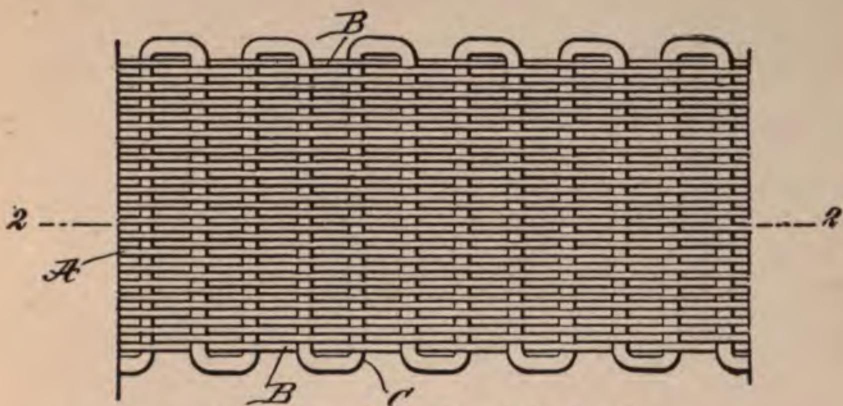


FIG. 42.—Plan View of Press-cloth, enlarged.

in the oil, which when present in the product requires to be eliminated by the process of filtration. Besides this objection the presence of sediment serves to deteriorate the quality of the oil, to reduce the quantity of oil as the net result of the pressure and the filtration, and the settling-tanks require frequent cleaning, and, finally, the residue with the sediment must be repressed or is entirely lost. If re-pressed, the residue produces a dark and inferior cake. The employment of hair mats overcomes these practical objections and secures good drainage facilities for the passage and escape of the oil; but in this present invention it is aimed to produce a mat of superior durability, owing to the soft tread or cushion which is afforded by soft weft-threads for the comparatively hard or coarse warp-threads in the body of the mat.

"The present invention contemplates an oil-press mat or cloth consisting of warp-threads and weft-threads, said warp-threads being composed of hard, stiff, coarse, and long animal hair and the weft-threads consisting of hard, stiff, coarse, and long animal hair mixed with soft, pliable, and long animal hair, the said warp-threads being greatly in excess per square inch of the weft-threads and in such close proximity to each other as to cover and protect the weft-

threads, the warp-threads forming the selvage consisting of soft pliable hair.

"Reference is to be had to the accompanying drawings, in which similar characters of reference indicate corresponding parts in both the figures.

"Fig. 42 is a plan view of a portion of an oil-press cloth or mat constructed in accordance with the present invention, and Fig. 43 is a sectional elevation of the same in the plane of the dotted line 2 2 of Fig. 42.

"The mat or cloth shown by the drawings consists of a plurality of longitudinal warp threads or strands *A* in the main or body

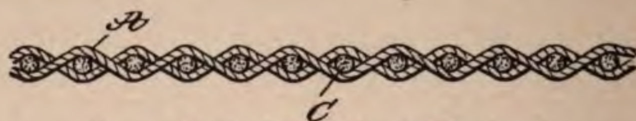


FIG. 43.—Sectional View of Press-cloth, enlarged.

portion thereof, a proper number of longitudinal warp-threads *B* at the selvage, and the weft-threads *C*, arranged to extend transversely across the body and selvage warp-threads and interlaced or interwoven therewith in a manner for the weft-threads to be entirely concealed and protected by the warp-threads.

"Previous to weaving the warp- and weft-threads for the production of the fabric or mat the threads or strands are prepared by selecting the proper kind of hair and twisting the same together in a manner to produce the threads or strands of proper size. The warp-threads in the body or main portion of the mat are made of animal hair which is long, hard, stiff, and coarse, and hair of this character having a thick and coarse filament is woven together to produce a strand of the proper length and thickness. The strands forming the weft-threads are made of two kinds of long animal hair—first, hair which is hard, stiff, and coarse, and, second, hair which is soft and pliable.

"It will be understood that in spinning the threads which are employed to produce the weft of the mat or cloth hair of medium texture is selected. As hair of this character is not readily obtainable, it is preferred to mix long strands of hard hair with similar

strands of soft hair, and thereby produce, in the technical phraseology of hair manufacturers, a product known as a 'medium' grade of hair. The threads having been properly intertwined to produce the weft-strands, the latter are employed in the manufacture of the mat so as to be interwoven with the warp-strands in the body and the selvage of the fabric.

"The warp-threads *A* in the body and the selvage warp-threads *B* are arranged alongside one another in parallel relation, while the weft-threads *C* extend across the warp-threads of the body and the selvage, so as to be covered thereby. The warp-threads in the body and the selvage of the cloth are from one to eight times in excess per square inch of the weft-threads in order to distribute the pressure of said warp-threads more evenly over the weft-threads. These weft-threads are from two to three times thicker than the warp-threads, and this is desirable because the weft-threads of increased thickness secure a more yielding and cushioning effect for the warp-threads.

"It is obvious that the employment of warp-threads which are as thick as the weft-threads will serve to concentrate the pressure at the points where the warp and weft intersect each other; but by the use of an increased number of warp-threads a corresponding increase in the points of engagement of the two threads is secured, thereby reducing the pressure which the weft-threads are called upon to sustain.

"The warp-threads *B* at the selvage are composed of long, soft, and pliable animal hair, the same being twisted together in order to secure strands which are more pliable than the warp-threads employed in the body of the mat or fabric.

"The use of warp-threads in the body of the mat having the peculiar characteristics hereinbefore described secures increased strength and durability in that portion of the cloth or mat which is most exposed to the pressure of the meats and the press-plates, and by weaving the cloth with the warps lying close together, so as to leave no space between adjacent warps, the meats are prevented from passing between the warps and coming in contact with the weft-threads, thus reducing the shearing strain of the meats upon the weft-threads and preventing the mat from splitting in a longi-

tudinal direction. The employment of selvage threads or strands made of soft hair at the edges of the mat minimizes the tendency of the mat to give way at the selvage, especially when the body of the mat is made of warp-threads which are comparatively harsh and coarse.

"The improved mat possesses all the desirable drainage properties which accrue from the use of animal hair, and at the same time it overcomes the objection so frequently encountered in breaking or shearing in the direction of its length and at the body portion thereof, owing to the greater strain at the middle of the body when the press is closed.

"Another advantage of the improved mat is that it may be folded longitudinally at any line either along the middle or side portions thereof. This folding of the mat can be accomplished without breaking or straining the same, owing to the longitudinal and parallel arrangement of the warp-strands and the employment of weft-strands, which are comparatively more pliable and fewer in number than the warp-strands."

Synopsis of Press-room Work.—The following is a synopsis of my * press-room work:

The meal comes into the press-room down through the chargers into the cookers. The charges are graduated so as to hold just 15 good full cakes.

If the meal is good and dry, I supply with live steam just enough moisture to make it form good cakes. If I am working "off" meal, no moisture is supplied, but cookers are ventilated so that excess of moisture is evaporated.

I think much depends on meal being of just the right consistency—not too wet nor too dry.

I have two 52-in. cookers, with two sweeps each traveling 75 revolutions per minute. Eight ball-breakers are suspended through top of cooker to within one inch of sweeps. When working good meal I carry a steam-pressure of from 50–60 lbs. on the cookers. I regulate this with a reducing-valve and keep the steam dry by using a steam-trap which automatically discharges the condensa-

* "Super" in *Oil-mill Gazeteer.*

tion. If meal is "off" I use higher pressure or more heat, according to the quality of meal.

I cook (one pressing at a time) from 12 to 20 minutes, usually making a "change" every 15 minutes, allowing 5 minutes to load and unload press; thus retaining a pressure of 3000 lbs. per square inch or 300 tons per 16-in. ram for 10 minutes. My cake will average about 12 lbs. each. Five or six pressings are put on a pair of trucks, weighed and carried to the adjoining meal-room and stacked to "dry out." The oil is carried from the two presses through pipes to the settling-tank underneath, and from there pumped to the storage-tanks.

This completes the press-room, which is all done by three men.

CHAPTER VI.

COTTONSEED PRODUCTS.

Characteristics of Cottonseed-oil. Coloring-matter of Cottonseed-oil. Tintometer. Crude Cottonseed-oil. The Filter-press. Barrels and Tank-cars. Crude Oil from Press to Shipping-tank. Determination of Free Acidity in Cottonseed-oil. Refining-test of Crude Cottonseed-oil. Commercial Grading of Soda-ash and Caustic Soda. Causticization of Soda-ash. Description of Causticizing Plant. Procedure of Causticization.

Characteristics of Cottonseed-oil.—Beyond the fact that fats and oils are mixtures of different glycerides in varying proportions, in which, in the solid fat, stearin or palmitin predominate, and in the liquid fat, olein, there is no sharp distinction in use between the terms. The terms as commonly used have reference more to physical consistency at ordinary temperature than to chemical constitution. A fat liquid at ordinary temperature receives the appellation, oil, and with oils of present commercial importance the characteristic constituent is the glyceride olein. These bodies are mixtures of different glycerides of different melting-points. Those termed oils we may regard as solutions of solid glycerides in a menstruum of liquid glycerides, which on reduction of temperature separate more or less completely. Advantage is taken of this characteristic to prepare the stearins of commerce.

Cottonseed-oil, like all animal and vegetable fats and oils, is, therefore, a mixture of different glycerides of different chemical and physical properties, which in the aggregate form the characteristics of the oil itself. It is evident that by removing any of the ingredients of the oil, the oil is to that degree modified.

Oil of vegetable origin is obtained chiefly from the seed in which it is present as minute drops within the cells forming the embryo. Its function is that of a reserve food-supply to be used

by the embryo during the early stages of germination and before sufficiently developed to absorb nutriment from the soil and air. The proportion in which it occurs in plants is inversely to the starch content, which body is reserved by the plant economy for the same purpose as the oil, and ranges from 71 per cent. in the edible portion of pecans to about 2 per cent. in barley. The oil as expressed from the embryo contains in solution and suspension numerous complex and unstable nitrogenous compounds which vary in amount according to the temperature of expression. Cold-pressed oils are very light in color. The removal of this extractive matter from the oil constitutes the work of refining. The decomposition of the oil is coexistent with its formation. The formation of free fatty acids begins in the seed and, after the expression of the oil, is accelerated by any delay in separating the accompanying nitrogenous substances.

Cottonseed-oil belongs to the class of oils termed "semi-drying," being intermediate, in the readiness with which it absorbs oxygen between "drying" oils, like linseed, and "non-drying" oils, like olive. This property resides in the presence of glycerides of unsaturated fatty acids, such as characterize linseed-oil. In addition to the predominant and characteristic glyceride olein, the glycerides, stearin, and palmitin, which form the "cottonseed-oil stearin" obtained in the preparation of winter oils, and the glycerides of unsaturated and hydroxy-acids, which impart to a greater or less degree the properties of drying oils, cottonseed-oil may contain according to its degree of purity varying amounts of the natural coloring-matter of the seed, together with complex and unstable nitrogenous compounds, and varying amounts of glycerides in different stages of decomposition.

As a result of the general and increasing use of cottonseed-oil for edible purposes there has arisen a voluminous literature devoted to the study of its properties and of its detection in products in which the occurrence of the oil is suspected. A study of these methods lies within the province of food analysis, with which the manufacturer of cottonseed-oil as a producer of a pure product has no direct interest.

The specific gravity of cottonseed-oil depends upon its purity,

temperature, and the proportion of solid glycerides present. The specific gravity diminishes as the purity increases and as the solid glycerides are removed. It may vary from 0.930 at 15° C. for crude oil to 0.9218 at 15° C. for summer white oil. The expansion of oil with increasing temperature is taken into practical consideration, under the rules governing transactions in cottonseed products,* for the determination of the number of gallons of oil from the weight at different temperatures.

The mean absolute coefficient of expansion for fats and oils, for 1° as determined by experiment, is almost exactly 0.0008.† In Table 8, Bull. 13, Div. of Chem., U. S. Dept. of Agr., is given the specific gravity of refined oil at different temperatures.

While cottonseed-oil is fluid at ordinary temperature, the fatty acids of the oil melt only at from 35° to 40° C. (95° to 122° Fahr.). The decomposition of the oil by the digester and Twitchell processes, as employed in the manufacture of candle material, whereby fatty acids are liberated and glycerol set free, permits the use of the oil for purposes for which in the natural state it would be unfitted.

Coloring-matter of Cottonseed-oil.—The color of cottonseed-oil arises from the presence of varying amounts of coloring-matter expressed from the seed with the oil. This coloring-matter is present in the seed in the brownish glands easily observed with the naked eye on cutting a section of the seed. On subjecting crude oil to the sulphuric-acid bleaching process, the coloring-matter is destroyed through the dehydrating action of the acid. The use of mineral dehydrating and oxidizing agents is, however, not permissible in oils intended for edible purposes. The removal of the coloring-matter introduced into the oil from the seed without impairing the quality of the oil for edible purposes is the task set before the refiner. J. Longmore,‡ in an examination of the unoxidized coloring-matter of the crude oil, states that it is a pungent golden-yellow powder slightly soluble in water, insoluble in acids but soluble in alcohol and alkaline solutions, and precipitating from the latter on the addition of acids. This substance is of no commercial value. It is estimated ‡ to be present to the extent of 15 pounds

* See Rules, Interstate Cottonseed Crushers' Association.

† Bull. 9, Office Exp. Sta., U. S. Dept. of Agr.

‡ Bull. 13, Div. of Chem., U. S. Dept. of Agr.

TABLE 8.—SPECIFIC GRAVITY OF REFINED COTTONSEED-OIL AT DIFFERENT TEMPERATURES.

[Water at 15° C. = 1. Average, oil at 15° = .9218; at 100° .8683.]

Temperature, C.°.	Specific Gravity.	Weight Cu. Foot Oil.	Temperature, C.°.	Specific Gravity.	Weight Cu. Foot Oil.	Temperature, C.°.	Specific Gravity.	Weight Cu. Foot Oil.
		Pounds.			*Pounds.*			*Pounds.*
10	.9249	57.68	41	.9054	56.46	72	.8858	55.25
11	.9243	57.63	42	.9048	56.42	73	.8851	55.20
12	.9237	57.60	43	.9043	56.38	74	.8845	55.16
13	.9231	57.55	44	.9035	56.34	75	.8839	55.13
14	.9224	57.51	45	.9029	56.30	76	.8832	55.19
15	.9218	57.49	46	.9022	56.26	77	.8826	55.05
16	.9212	57.45	47	.9016	56.23	78	.8820	55.01
17	.9206	57.41	48	.9010	56.18	79	.8814	54.98
18	.9199	57.35	49	.9004	56.13	80	.8807	54.94
19	.9193	57.31	50	.8997	56.10	81	.8801	54.90
20	.9187	57.28	51	.8991	56.07	82	.8795	54.86
21	.9181	57.25	52	.8984	56.03	83	.8788	54.80
22	.9174	57.21	53	.8978	55.99	84	.8782	54.76
23	.9168	57.18	54	.8972	55.95	85	.8776	54.73
24	.9161	57.13	55	.8966	55.91	86	.8769	54.68
25	.9155	57.08	56	.8958	55.86	87	.8763	54.64
26	.9149	57.04	57	.8953	55.82	88	.8757	54.60
27	.9143	56.00	58	.8946	55.78	89	.8751	54.56
28	.9136	56.97	59	.8940	55.74	90	.8744	54.53
29	.9129	56.93	60	.8934	55.71	91	.8738	54.49
30	.9193	56.89	61	.8927	55.67	92	.8732	54.45
31	.9117	56.85	62	.8921	55.63	93	.8725	54.40
32	.9110	56.81	63	.8915	55.59	94	.8719	54.36
33	.9105	56.75	64	.8908	55.55	95	.8712	54.31
34	.9098	56.74	65	.8902	55.51	96	.8706	54.28
35	.9092	56.70	66	.8896	55.51	97	.8700	54.24
36	.9086	56.66	67	.8890	55.48	98	.8695	54.20
37	.9079	56.61	68	.8883	55.39	99	.8689	54.16
38	.9073	56.58	69	.8877	55.35	100	.8683	54.10
39	.9067	56.54	70	.8870	55.31			
40	.9060	56.50	71	.8864	55.28			

per ton of crude oil. This proportion, however, must vary considerably.

Tintometer.—The determination of color of refined oils is an important consideration in their classification and grading. The Interstate Cottonseed Crushers' Association recommend for this purpose the use of the Lovibond tintometer, and in accordance with the arbitrary color scale of this instrument declare that prime summer yellow oil shall have no deeper color than 35 yellow and 7.1 red.

The color examination is made as follows:

The oil is placed in a colorless four-ounce sample bottle; the depth of the oil in the bottle shall be 5½ inches. The bottle shall

be placed in a tintometer, which is protected from any light except reflected white light, and the reading made at a temperature of about 70° Fahr. If the oil is of a deeper color than the glass standard, 35 yellow and 7.1 red, it shall not be prime.

The tintometer was devised some years ago by J. W. Lovibond, of Salisbury, England, for the purpose of measuring and recording the colors of liquids and solids.

Any one, unless color-blind, can use the instrument with accuracy.

The tintometer consists of a simple apparatus for holding the object under examination and the standard color glasses.

These standard glasses consist of three scales—red, yellow, and blue—and are numbered according to their depth of color. All possible shades and combinations of color can be matched by combinations of red, yellow, and blue, and it can readily be understood that the character and depth of color of any liquid or solid can be measured in the tintometer by simply matching the color of the object under examination with the appropriate glasses.

Each of these colored scales, as said above, consists of a large number of glass slips of different depths of the same color, namely, either blue, red, or yellow, as the case may be. Each scale grades from the very lightest shade to the darkest.

The intervals between the units or main divisions of the scales are equal and may be considered as the smallest difference in the deeper shades which the normal eye can observe. In the lighter shades of each scale the unit divisions are divided into tenths and hundredths as the discriminating power of the eye is here increased.

The actual dimensions of the color unit are arbitrary, but this is of no importance, as the divisions of the scales are equal and equivalent and serve admirably for practical work. The tintometer scales are not more arbitrary than any other measurement standard, and, what is important, do not change.

The colors are stable and do not fade, and it is satisfactory to know that a standard glass in use to-day will be of the same color depth to-morrow or ten years hence and can be relied upon.

Again, if all the glass standards in use were destroyed, new scales exactly corresponding to the original scales could be prepared. For instance, if a stable freshly prepared chemical solution of known

percentage has once been accurately measured by the standard glasses and recorded in color units, that record could always be used as a basis of testing the validity of a unit or used as the basis for the construction of an entire new scale which would exactly duplicate the original.

The tintometer color standard for prime summer yellow cottonseed-oil, adopted by the Interstate Cottonseed Crushers' Association, is not a new standard for the grading of oil, but simply the adoption of an accurate method for recording the present standard.

As there is no blue in the color composition of prime summer yellow only glasses from the yellow and red scales are used for this standard. The standard adopted as the deepest color which $5\frac{1}{4}$ inches of refined cottonseed-oil could exhibit and still be of prime color, consists of 35 yellow units on the yellow scale combined with 7.1 red units on the red scale.

It will no doubt be surprising to some to learn that prime oil has so much red in its color composition, but it is a fact which is demonstrated by the use of the tintometer. Even the choicest white oil has some red in its color composition.

The apparatus for holding the bottle of cottonseed-oil and the standard prime summer yellow glasses consists of a box about 14 to 16 inches long with a cross-section of about 2×4 inches.

At one end is a suitable arrangement for holding the bottle and the colored slips of glass. At the other end are peep-holes for the eyes. Across the interior of the box is a diaphragm containing two round holes so arranged that one covers the mouth of the bottle and the other is over the color glass.

When examining the color of an oil the instrument is held vertically over a sheet of white paper or porcelain which reflects white light up through the column of oil and up through the standard glass to the eyes. The head is held close to the upper end of the instrument and two bright round discs of color are seen, one of which is the oil, the other glass. With a little practice the eyes can note the slightest differences of color.

Cottonseed Products—Crude Cottonseed-oil.—The crude oil as it flows from the press is thickly fluid and of varying color, ranging from reddish-brown to black. It is contaminated with water,

the native moisture of the seed not expelled in cooking, and varying proportions of albuminous and coloring-matter residing in the seed, to the character and amount of which the color of the crude oil is due. The color of the crude oil, aside from refining tests, is the most valuable index of its quality. The properties of crude oil are determined by the character of the seed and the thoroughness of the cooking process. If the seed have been allowed to heat, or ferment, in storage, the color of the resulting oil is invariably affected, the degree of injury in this respect varying with the degree of change the seed have undergone, whether the fermentation has been slight or of short duration or advanced to the degree styled "rotten." Hasty or insufficient cooking likewise has its deleterious effect upon the color of the oil. Odor and flavor of the crude oil are valuable indices of the condition of the seed.

The value of crude oil is determined by the proportion of refined oil it will produce. This depends upon the amount of albuminous matter remaining after settling and upon the degree of decomposition the oil has undergone. The relation of color, amount of albuminous matter present, degree of decomposition, and yield on refining are often contradictory and puzzling. The loss on refining is the important consideration in the judgment of crude oil and is one to which the other characteristics contribute. If the loss on refining and the quality of the resulting oil depended solely upon the degree of decomposition of the oil, the free fatty-acid test would suffice for learning the value of the oil. It is the experience of oil chemists that frequently a crude oil containing a low percentage of free fatty acids will yield an "off" grade of refined oil, and vice versa, a crude oil containing a high percentage of free fatty acids will yield prime refined oil. To the experienced man the flavor and color of the crude oil are ample indices of its value. While the free fatty-acid test is not an invariable index of the quality of refined oil obtainable, its exclusive use serves to indicate the partial loss on refining and to that extent is helpful.

The avoidance of decomposition of the neutral glycerides of the oil should be of constant concern. Any condition conducive to the decomposition of the unstable albuminous matter of the seed likewise favors the oxidation of the glycerides with the production

of free fatty acids. These conditions may arise at any time in the handling of the seed and are favored by the combined presence of heat, moisture, and air. The deleterious influence of these three factors of decomposition make clear the necessity of their rapid elimination not only from the seed themselves, but from the crude oil as well. Hence crude oil should not be allowed to remain long in contact with "foots," and, although free from "foots," with water or air, or both.

The comprehensive and true test of the value of crude oil consists of that process which will indicate the combined loss of moisture, free fatty acids, and albuminous and coloring matter. This is the refining test.

Crude cottonseed-oil is divided into three general grades, viz., prime, choice, and off. According to the rules governing transactions in cottonseed products, the three grades are defined as follows:

Crude cottonseed-oil to pass as prime must be made from sound decorticated seed; must be sweet in flavor and odor, free from water and settlings, and must produce prime summer yellow grade with the use of caustic soda by the best refining methods, with a loss in weight not exceeding 9 per cent., provided any oil that refines with a greater loss than 9 per cent., but still makes prime summer yellow grade, shall not be rejected, but shall be reduced in price by a corresponding per cent. of the contract price of the oil.

Choice crude oil must be made from sound decorticated seed, must be sweet in flavor and odor, free from water and settlings, and shall produce, when properly refined, choice summer yellow oil at a loss in weight not exceeding 6 per cent. for Texas oil and 7 per cent. for oil from other parts of the country.

Oil neither choice nor prime shall be called "Off" oil, and should be sold by sample.

The yield of crude oil per ton of seed is a variable factor, depending, as has been stated, upon geographical and climatic conditions, as regards the cotton-plant, and upon the care used in the manipulation of the seed; thus there are diverse and numerous influences affecting the yield. By reference to Table 3, the average yield of oil by States in the cotton-growing section, and for the entire sec-

tion, is given. While there may be numerous instances of higher yields in particular cases, the figures stated have the merit of a general, close approximation to accuracy for the entire territory. The yield of 37.6 gallons (282.7 lbs.) is the average of yields, by States, that range from 35.3 gallons in the Indian Territory to 40.8 gallons in North Carolina. American seed yields a clearer oil than the Egyptian or Indian seed, and the uplands seed produces a clearer oil than that from our seacoast. The oil made in Great Britain is not so clear as ours, first, because the seed is mostly Egyptian or Indian, and secondly, because it has not been decorticated. The climate has much to do with the quality of the oil. In some years, owing to more favorable weather conditions, the oil obtained from the seed grown in the western section of the cotton belt is better than that grown in the eastern section, while in other years it is just the reverse. It has been observed at cottonseed-oil mills that in general seed in a wet season contains more oil of poorer quality than in a dry season, but little is known of the change in its composition due to different conditions.

The crude oil as it flows from the press is pumped to the storage-tank. As stated before, among the requirements for prime crude is freedom from water and settlings. These separate on standing in the storage-tank and the supernatant, settled oil is racked or pumped off as required. This mode of handling the oil in the crude-oil mills was general until a comparatively recent date. This method of separation was a fertile source of trouble, not alone in deterioration of the oil from prolonged standing in contact with moisture and settlings, which invariably injures the oil, but in frequent mixing of the settlings with the crude oil when taken off. The use of the filter-press in the handling of the crude oil has greatly facilitated the process in that the quality of the crude has been improved and the handling of the troublesome "foots," or settlings, made easier. With the use of the filter-press the crude oil is handled after the following manner: Two tanks of about 100 barrels capacity are provided. The fresh oil from the press is allowed to flow into one until filled, when the oil is turned into the second tank and the filtration of oil in the first tank started, the filtered oil being discharged into the storage-tank. When the second

tank is filled, the first tank is empty and again ready for fresh oil. When the filter-press is filled, it is opened and cleaned.

The solid matter, consisting of meal which under the old system would have remained either in suspension or precipitated to form part of the foots, in either case a fertile source of deterioration to the oil, is returned to the meal-bin to be re-cooked and worked over with fresh material. Filtered crude, being thus free from all particles of the non-oleaginous portion of the seed which in their decomposition impair the quality of the oil, retains its sweetness and purity for a long time. Moreover, as a result of a few hours' use of the press, the oil is obtained in better condition than could be obtained by the old system of sedimentation, the time-saving being considerable. In pumping oil from the storage-tank to tank-cars or to barrels, frequent observations should be made during the discharge to insure uniformity of quality and particularly that the oil is clear.

The Filter-press.—The modern filter-press, Fig. 44, represents the old bag filter in a multiplied and more highly efficient form and is an indispensable medium for the clarification of oil. In cottonseed-oil refining it is used for the separation of suspended impurities of crude oil, and for the separation of fullers' earth used in the decolorization of refined oil. It consists essentially of a number of cast-iron plates, grooved in various ways to facilitate the egress of the oil through the filtering medium, which may be either cloth or paper according to the material filtered and the pressure with which it is forced through. Closely woven duck is used for cottonseed-oil. The plates are provided with an opening which may be in either the centre, circumference, or corner according as the plates are circular or square; also an outlet for the discharge of the filtrate, which likewise may be variously located. The plates are covered with cloth hanging loosely over it but made tight around the opening previously mentioned by means of a hollow flanged screw. The plates thus prepared are set in the frame of the press which supports them by means of lugs on either side of each plate, and the whole tightened, with the result that there is formed a series of cloth-lined filtering chambers for the deposition of solid matter in layers or cakes. The oil is pumped into the press and into each chamber

through the opening in the plate and cloth and finds egress through the outlet in each plate.

As filtration takes place on both sides of each filtering chamber, the deposit forming the cake is built up gradually, which in so doing increases the depth of the filtering medium, until it meets in the middle. At this stage filtration is retarded by the quantity of solid matter in the chambers and when completely filled filtration ceases.

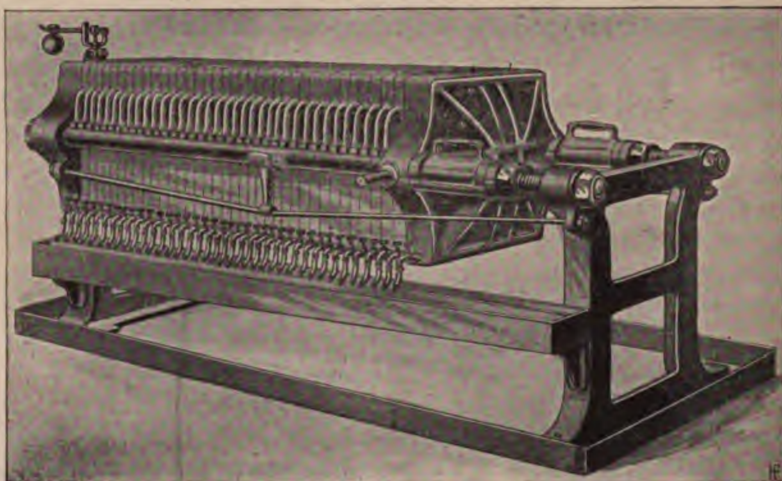


FIG. 44.—Thirty-inch Filter-press with Thirty-six Plates.

The residual oil in the cake may be blown out with either steam or compressed air. These portions should be returned to the crude tank. The efficiency of a filter-press depends upon the construction of the plate (Fig. 45); its capacity depends upon the dimensions of the plate, which may vary from 18 to 36 inches square with square plates and from 18 to 36 inches diameter with round plates, and upon the number of plates which is determined by the amount and character of the material to be filtered. The thickness of the cake may be increased within practicable limits by the insertion of frames (Fig. 46). The switch-cock and double gutter shown in Fig. 47 are a very useful arrangement for separating press washings from the clear filtrate. In case of an accident to the cloth while the press is in operation, the turbid filtrate from any chamber can be returned

to the crude tank by directing the flow from that chamber by means of this device into the gutter emptying into that tank.

FIG. 45.—Filter-press Plate.

FIG. 46.—Filter-press Frame.

The use of the filter-press for removing suspended matter from fresh crude oil, with the necessary connections and relative location of tanks and press, is shown in Fig. 48.

A 24-inch press is located on a platform above the crude- and filtered-oil tanks, the former of which receives the fresh oil directly from the hydraulic press. The pump receives the crude oil from

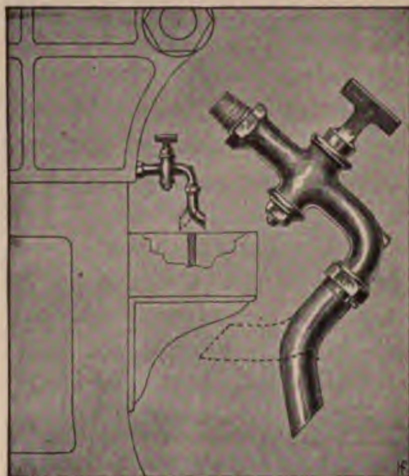


FIG. 47.—Switch-cock and Double Gutter.

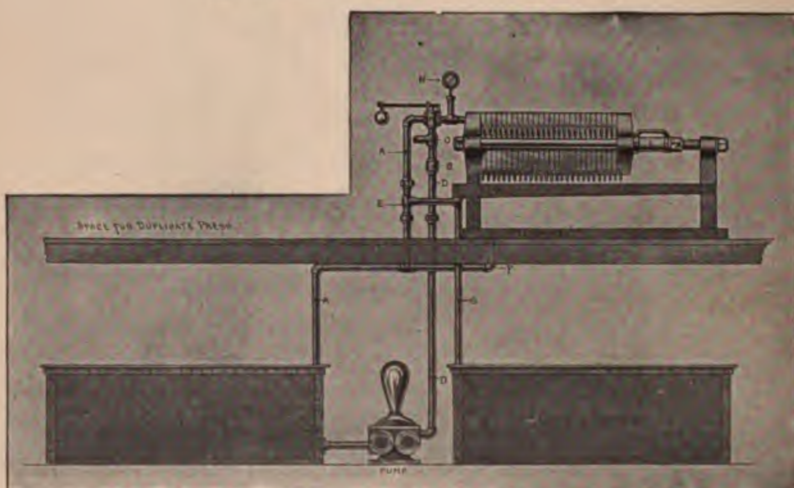


FIG. 48.—Filter-press Plant for Crude Cottonseed-oil.

the crude tank and forces it through the pipe D to the press. The gauge and air-chamber N are connected to the head of the

press; to this is screwed the relief valve *M*. Below this the tee *Q* is connected to receive the steam- or air-supply for blowing out the press. Below this comes the check-valve *B*, then the union connecting pipe *D* leading to the discharge-pipe or the pump. Where the press is equipped with switch-cocks and double gutter, the wide portion of the gutter *K*, which takes the filtered oil, should be connected to the filtered-oil tank through pipe *G*, and the other portion of the gutter should be connected by pipe *E* to the crude tank. The drip-pan of the press should be connected by pipe *F* to the crude pipe *A*.

When the chambers are filled with solid matter, filtration ceases, relief valve *M* opens and returns the crude oil to the crude tank. This stage is indicated in advance by the reduced filtrate and increased pressure on the gauge. The press is now steamed or blown out, the washings being returned to the crude tank. The nuts on the side screws are then loosened and the blocks *L* taken off. A man on each side of the press shoves back and loosens each cake, which drops in the pan beneath the press. After removing the cake the press is tightened up and is again ready for use.

Barrels and Tank-cars.—The penetrative power of cottonseed-oil and the readiness with which the refined oil absorbs odors and becomes tainted require that all packages containing it be thoroughly clean and absolutely tight. In former years second-hand barrels, chiefly from the linseed-oil and petroleum industries, were commonly used, with the result that much dissatisfaction was created by deterioration of flavor of the oil by contact with imperfectly cleaned barrels. Rules governing transactions in cottonseed products now require that barrels for refined oil must be good, new, hard-wood iron-bound barrels or thoroughly cleaned refined cotton-oil barrels painted or varnished, and must be delivered in good shipping order. The requirements of barrels for crude oil are not so stringent. It is required that barrels for crude oil shall be good, new, iron-bound barrels, properly silicated, or thoroughly steamed and cleaned refined-petroleum barrels.

The specifications for a cottonseed-oil barrel demand that it shall be made of hard wood, usually oak, thoroughly seasoned and

provided with at least six heavy iron hoops fitted perfectly tight. For the prevention of leaks, the barrels are coated on the inside with silicate-of-soda solution.

Tank-cars were originally used for transporting petroleum. The superior economy of their use in shipping large quantities of similar material was soon recognized and they are now generally employed for linseed-oil, cottonseed-oil, molasses, tallow, lard, etc. For cottonseed-oil, they are commonly used for transporting crude oil to refineries and refined oil to large consumers. They are provided with steam-pipes for melting any solidified oil. In shipping refined oil in tank-cars the necessity for cleanliness prevails likewise as for barrels.

Crude Oil from Press to Shipping-tank.*—Crude oil as it comes from the press has more or less meal, lint, and other substances in it, according as to the manner in which the meal has been cooked and the presses worked.

Leaving all the impurities in the oil would produce sour and rancid oil, off in quality, color, and flavor, and such oil could not be stored. To remove these impurities from the oil we should use a filter-press, or have some way to settle the oil thoroughly.

A filter-press is decidedly the best, as it takes out all impurities, producing a clean, clear oil, and this will keep in storage-tanks a long time without losing its good grade.

Oil can be settled by having a large trough or series of troughs back of the presses running the oil back and forth, with a pitch so as to let oil run very slowly. Place sieves or perforated iron at several places, decreasing meshes or holes toward end of flow. A shallow and wide trough will be better than a narrow and deep one, as oil is spread over more surface and will settle better, and the troughs will catch the most of your meal. Use a scoop made of perforated iron to remove the meal, or use a wooden paddle hollowed out with holes drilled in it to let the oil percolate through. Put the meal in buckets and let it stand until it settles, then pour off the oil and press the meal over again. Have a tank large enough for two hours' run

* A paper by S. Wunderlich, Waco, Texas, and S. J. Duke, Pittsburgh, Texas, read before Texas Cottonseed Crushers' Association, Sherman, Texas, May 27, 28, 29, 1903.

to run oil in from trough, and pump same out every two hours; in the tank there will be a good deal of meal caught again. Oil can in this way be settled very well, and can be pumped to storage-tank.

A better way is to have four or five settling-tanks; build a large trough above these tanks, say about twenty feet long with about eight or ten partitions; pump oil from your tank in back of the presses into the first partition so that it will have to travel from one to another, and place sieves in same as in back of the presses; from here run a pipe nearly down to bottom of tank No. 1; have all the tanks connected on top running from one to another, so if tank 1 is full it goes on to tank No. 2 and so on to No. 5. When No. 5 gets full pump out to the storage-tank. Once every week the storage-tanks should be pumped out; Monday morning would be the best time, and you will find that tanks Nos. 2, 3, 4, and 5 never have any tank bottoms or "foots" in them. A very slow and continuous flow of oil as long as it is warm will also cause it to settle well. Oil handled this way will keep its grade and can be stored a long time. By using the above process I have never had any soap-stock, "foots" or tank bottoms at the end of the season.

Now in regard to oil: good prime seed should make good prime oil; after it is made keep it so; keep everything around your presses clean; do not allow any waste meal to accumulate around your presses, so that it will sour and afterward be put in with your good meal; work meal and presses so as not to make so much waste; cleanliness is an absolute necessity around the presses; have all connections from hydraulic pipes and valves tight; do not allow pump-oil and oil from rams to get into the good oil; the result would be that instead of prime oil you would have an off grade of oil.

To load tank-cars, they should be closely inspected; take off dome-cap and valve-cap to air the tank if it is foul-smelling and gummed on the inside; clean the tank thoroughly either by steam or hot water; then wipe out clean and dry. That is very important and should be done in the most thorough manner.

Determination of Free Fatty Acids in Cottonseed-oil.—The percentage of free fatty acids in crude oil is a valuable index of the quality of the oil in so far as it serves to indicate the approximate loss on refining. It is not to be relied upon as indicating the quality

of the refined oil that can be obtained. The free fatty-acid test indicates composition.

Procedure.—About 5 grams of the sample are weighed out in a wide-mouthed Erlenmeyer flask of 250 cubic centimeters capacity and 50 cubic centimeters of 95 per cent. neutral alcohol are added. Insert in mouth of flask a stopper bearing a long glass tube to serve as an air return-flow condenser, and heat the whole on a water-bath, with occasional shaking, for about five minutes. Remove the condenser, add phenolphthalein as indicator and titrate with semi-normal caustic soda solution. Calculate the free acidity in terms of oleic acid with molecular weight of 282. Phenolphthalein is pink with alkali and colorless with acid. The color of the sample may be so pronounced as to interfere with a close determination of the end-point, in which case the alcoholic solution should be diluted, either by the direct addition of 95 per cent. neutral alcohol or by the use of a less weight of the sample. Duplicate determinations should be made to insure accuracy. To calculate percentage of free fatty acids, multiply the number of cubic centimeters of semi-normal caustic soda solution used by the value of one cubic centimeter of the same solution expressed in terms of oleic acid and divide the product by the weight of sample taken.

According to rules governing transactions in cottonseed products, choice crude oil should not test over 1 per cent. of free fatty acids.

Refining Test of Crude Cottonseed-oil.—The refining test of crude oil comprises the saturation of the free fatty acids with an excess of caustic soda solution of various densities from 10° to 20° Bé. and allowing the soap mixed with albuminous and coloring matters of the oil to settle and solidify. The clear yellow supernatant oil is removed by means of a pipette and weighed. The difference between the weight of crude oil taken and the weight of clear oil obtained is the loss on refining and is expressed in percentage by dividing by the weight of crude oil taken. The quality of the oil may be further determined by subjecting the yellow oil obtained as above described to the bleaching test. The bleaching test consists in agitating a known weight of the yellow oil in a porcelain dish with a known weight of fuller's earth at a temperature

not exceeding that allowed in refining summer yellow oil on a practical scale. The mixture is slowly heated and the fullers' earth stirred in with a thermometer. When the maximum temperature, viz., 125° to 135° Fahr., is reached, the oil is filtered through filter-paper into 4-ounce oil sample bottles and the color and flavor observed. Different percentages of fullers' earth are used on different portions of the same sample. In this manner the minimum percentage of earth producing an oil of highest brilliancy is ascertained. This percentage of earth thus determined experimentally is used by the bleacher.

Commercial Grading of Soda-ash and Caustic Soda.—The system of grading alkali and caustic is based upon the molecular composition of these bodies, and the quotations of the various grades in terms respectively of 48 per cent. alkali and 60 per cent. caustic is a vestigial characteristic of the early Leblanc days and an evidence of the highest grades of those products they were then mechanically able to produce. The molecular weight of sodium carbonate, Na_2CO_3, is 106, composed of 62 parts by weight, or 58.49 per cent. of Na_2O, the remainder being CO_2. A soda-ash that contains 58.49 per cent. of Na_2O is therefore chemically pure, this percentage being equivalent to 100 per cent. Na_2CO_3. A 58 per cent. alkali should contain 58 per cent. of Na_2O or its equivalent, 99.16 per cent. Na_2CO_3; likewise a 48 per cent. alkali should contain 48 per cent. Na_2O or its equivalent, 82 per cent. Na_2CO_3. The reduction of any grade of soda to that of 48 per cent. is effected by admixture with common salt. There are present for comparison two fairly representative analyses of these two standard grades of soda-ash:

Grade.	Per Cent. Na_2CO_3.	Per Cent. NaCl.	Per Cent. Na_2SO_4.
48%	60.64	28.34	4.35
58%	98.72	.54	.20

Grade.	Per Cent. NaOH.	$F_2O_3Al_2O_3SiO_2$.	$CaCO_3MgCO_3$.	H_2O.
48%	1.29	1.12	Traces.	4.26
58%	....	.10	.17	.26

Caustic soda occurs on the market in a variety of grades and is sold on the basis of 60 per cent. of Na_2O. Caustic soda as a product of the alkali industry did not arise until thirty years after the industry was established in Great Britain, and the expression

of its quality in the same terms as that of soda-ash might be expected. The molecular weight of caustic soda is 40; to arrive at sodium oxide, Na_2O, as an expression of the customary unit two molecules with a total molecular weight of 80 are used. In $2NaOH$ there are 62 parts, or $77\frac{1}{2}$ per cent. Na_2O, the remainder being H_2O. Therefore a chemically pure caustic soda contains $77\frac{1}{2}$ per cent. Na_2O, or its equivalent, 100 per cent. NaOH. There is for purpose of comparison in the following table the percentage of the essential ingredient corresponding to, but never present in, the various grades of caustic commonly found in the market:

Grade.	Per Cent. NaOH.
60-degree	77.42
70 "	90.32
72 "	92.90
74 "	95.48
76 "	98.06
77 "	99.35
$77\frac{1}{2}$ "	100.00

Sodium chloride, sodium carbonate, and sodium sulphate, in varying proportions, constitute chiefly the remainder of the ingredients. With the present system of grading based upon the chemical determination of the total alkali, the Na_2O of the Na_2CO_3 is estimated with the Na_2O, in terms of which the caustic soda or NaOH is expressed. With this method of expressing the quality of the caustic, the soap-maker has just cause for complaint in that a variable percentage of a worthless ingredient is included in the total percentage of the essential ingredient present. The following is an analysis of a sample of commercial caustic purporting to be of 74 per cent. quality:

Total alkali estimated	as Na_2O	74.18%	
Caustic alkali "	" "	69.88%	
Caustic alkali "	" NaOH		90.18%
Combined alkali "	" Na_2CO_3		7.35%
Combined alkali "	" Na_2O	4.30%	
Sodium chloride "	" NaCl		2.02%

This analysis indicates sample to be of substantially 70 per cent. quality. The difference between the sodium hydrate actually present

and that claimed, viz., 4.30 per cent. Na_2O, is due to the 7.35 per cent. Na_2CO_3, this being estimated as its equivalent, 4.30 per cent. Na_2O, in the total sodium oxide. As more or less carbonate is invariably present in all commercial caustic, especially in the lower grades, the system of including it in the expression of the quality of this product is open to severe criticism. Quotations of quality are thus confessedly a misrepresentation. The only rational method is the expression of the Na_2O as free caustic, or preferably units of NaOH.

This would be an absolute index of the value of the caustic as a saponifying agent, and not, as by the method in vogue, an uncertain approximation of the same. English degrees indicate the strength of the ash or caustic in terms of Na_2O, but, owing to either a wilful or accidental error in atomic weights, English analyses indicate a greater percentage of Na_2O than is actually present. This error has become so firmly established by tradition that modern ideas have been unable as yet to eliminate it. In Germany and Russia the strength is expressed in terms of sodium carbonate. This system is perfectly rational when applied to soda-ash, but is inconsistent when applied to caustic. The expression of the value of commercial caustic soda in terms of an impurity, which, in so far as the soap industry is concerned, is positively worthless as a saponifying agent for neutral glycerides, is certainly not conducive to clear ideas on the subject.

The superior advantages and economy of high-grade caustic need no argument. It is true of this product that the best within certain limits is the cheapest. There is presented in the following table the price per pound of sodium hydrate as it occurs in the customary grades of caustic, assuming that no carbonate is estimated as caustic:

CAUSTIC SODA.

Grade.	Price per 100 Pounds.	Per Cent. NaOH Present.	Price NaOH per 100 Pounds.
60%.................	$1.65	77.42	$2.131
70%.................	1.50 for 60%	90.32	1.937
74%.................	1.60 for 60%	95.48	2.066
76%.................	1.70 for 60%	98.06	2.196

The anomalous variation in prices quoted arises from the slight differences in cost of production of the lower grades, combined, for those grades, with the proportionally greater cost of packages, transportation, etc.

The total charges contingent upon marketing a 60 per cent. caustic are the same as those of a 70 per cent., although the former contains considerably less of the essential ingredient; also the cost of production of a 70 per cent. caustic is but little more than that of 60 per cent. The increased cost of production of the higher grades, viz., 74 per cent. and 76 per cent., makes necessary a higher price, which is less than it would be if cost of marketing were correspondingly increased.

The system of quoting the higher grades in terms of 60 per cent. caustic is a peculiarity of the trade, and the fractional increase in price based upon the degree is a measure of the increased cost of carrying the manufacture of the product above the 60 per cent. grade.

In the preparation of caustic lyes of different densities from various grades of caustic, the influence of the impurities, chiefly sodium chloride, sodium carbonate, and sodium sulphate, is to reduce the active value of the solution for the specific gravity indicated. This reduction in saponifying power is least for the highest grades and greatest for the lowest as a natural result of the increased percentage of these impurities present. The following table indicates the percentage of sodium hydrate present in lyes of different densities, made of the usual grades of caustic, corresponding to the densities of lye made from chemically pure caustic. It is assumed that the total alkali is present entirely as caustic, which never actually occurs. The figures stated, for reasons previously given, are generally slightly higher than would be found in practice. However, the table possesses value as a basis of comparison, and for all technical purposes the figures are sufficiently accurate.

Causticization of Soda-ash.—The consumption of caustic soda for oil-refining and soap-making may be of sufficient amount, together with other economic considerations, to warrant the manufacturer undertaking the manufacture of caustic soda himself. Caustic soda in aqueous solution is obtained from soda-ash, i.e.,

TABLE 9.—PERCENTAGE OF SODIUM HYDRATE IN LYES MADE FROM VARIOUS GRADES OF COMMERCIAL CAUSTIC.

Specific Gravity.	Degrees Bé.	Grades of Caustic.						Degrees Twaddell.
		77½°.	76°.	74°.	72°.	70°.	60°.	
		Per Cent. NaOH.						
1.075	10	6.55	6.42	6.25	6.08	5.91	5.06	15.0
1.083	11	7.31	7.17	6.98	6.79	6.60	5.66	16.6
1.091	12	8.00	7.84	7.63	7.43	7.22	6.19	18.2
1.100	13	8.68	8.51	8.29	8.06	7.84	6.72	20.0
1.108	14	9.42	9.24	8.99	8.75	8.51	7.29	21.6
1.116	15	10.06	9.86	9.60	9.34	9.08	7.78	23.2
1.125	16	10.97	10.76	10.47	10.20	9.91	8.49	25.0
1.134	17	11.84	11.61	11.31	11.00	10.69	9.17	26.8
1.142	18	12.64	12.40	12.07	11.74	11.41	9.78	28.4
1.152	19	13.55	13.28	12.93	12.59	12.24	10.49	30.4
1.162	20	14.37	14.09	13.72	13.35	12.97	11.12	32.4
1.171	21	15.13	14.84	14.44	14.06	13.67	11.71	34.2
1.180	22	15.91	15.61	15.19	14.78	14.36	12.31	36.0
1.190	23	16.77	16.44	16.01	15.58	15.15	12.98	38.0
1.200	24	17.67	17.33	16.87	16.42	15.96	13.68	40.0
1.210	25	18.58	18.23	17.74	17.27	16.78	14.38	42.0
1.220	26	19.58	19.20	18.69	18.19	17.68	15.16	44.0
1.231	27	20.59	20.19	19.66	19.13	18.60	15.94	46.2
1.241	28	21.42	20.99	20.44	19.89	19.33	16.57	48.2
1.252	29	22.64	22.20	21.62	21.03	20.45	17.53	50.4
1.263	30	23.67	23.21	22.60	21.99	21.37	18.32	52.6
1.274	31	24.81	24.33	23.69	23.05	22.42	19.21	54.8
1.285	32	25.80	25.30	24.63	23.96	23.30	19.97	57.0
1.297	33	26.83	26.31	25.62	24.92	24.23	20.77	59.4
1.308	34	27.80	27.26	26.55	25.82	25.11	21.52	61.6
1.320	35	28.83	28.28	27.53	26.79	26.04	22.31	64.0
1.332	36	29.93	29.35	28.58	27.81	27.04	23.17	66.4
1.345	37	31.22	30.62	29.82	29.00	28.46	24.40	69.0
1.357	38	32.47	31.84	30.99	30.16	29.32	25.13	71.4

commercial sodium carbonate, by treating the latter, under suitable conditions, with slaked lime. The procedure of manufacture is in accordance with the following chemical reaction:

$$\underset{106}{Na_2CO_3}\text{(soda-ash)} + \underset{74}{Ca(OH)_2}\text{(slaked lime)}$$
$$= \underset{100}{CaCO_3}\text{(lime-mud)} + \underset{80}{2NaOH}\text{(caustic soda)}.$$

Thus, theoretically, 106 parts of sodium carbonate treated with 74 parts of calcium hydrate yield 100 parts of calcium carbonate and 80 parts of sodium hydrate. On a practical scale the theoretical yield is only approximately attained.

Description of Plant.—In Fig. 50 is shown, in plan and elevation, the mechanical equipment of a causticizing plant, consisting of the converting-kettle, screen-tank, lye storage-tank, evaporator, pumps, etc. Fig. 49 is a conventional form of lime-house. Fig. 51

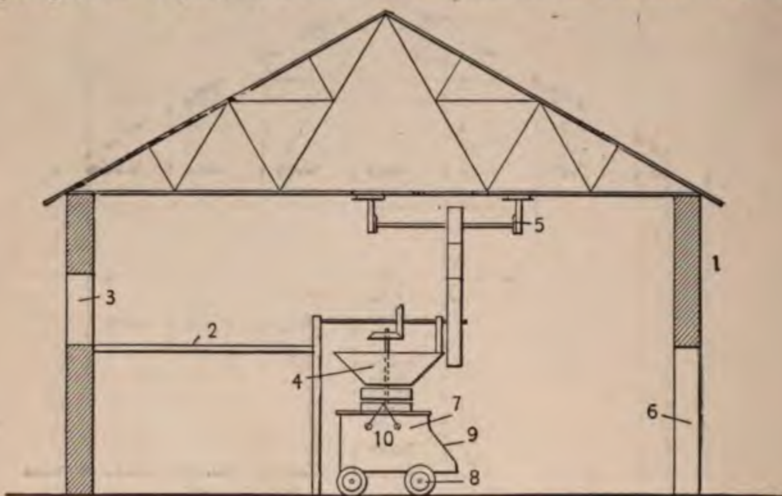


FIG. 49.—Conventional Form of Lime-house.

is an enlarged sectional view of the screen-tank; and Fig. 52 is an enlarged sectional view of the lower portion of the converting-kettle.

It is best to provide a building or a suitable fire-proof room or inclosure for the storage and preparation of the lime to be used in the converting-kettles, and as imperfectly burnt or inferior qualities of lime often contain stone or unburnt material, such is preferably crushed before being passed to the converting-kettle, as it also affords an easier, more rapid, and complete operation in the converting-kettle.

In Fig. 49, 1 represents the lime-house, having a raised or elevated iron floor 2 for the storage of the lime. Adjacent to one side of this elevated floor is a door 3, through which the lime can be received.

4 is a lime-mill or crusher operated by a suitable power, a counter-shaft 5 being shown. The crushed lime from the mill may be passed directly into the carrier 7, which may be of perforated iron if it is to be used as a basket inside of the converting-kettles,

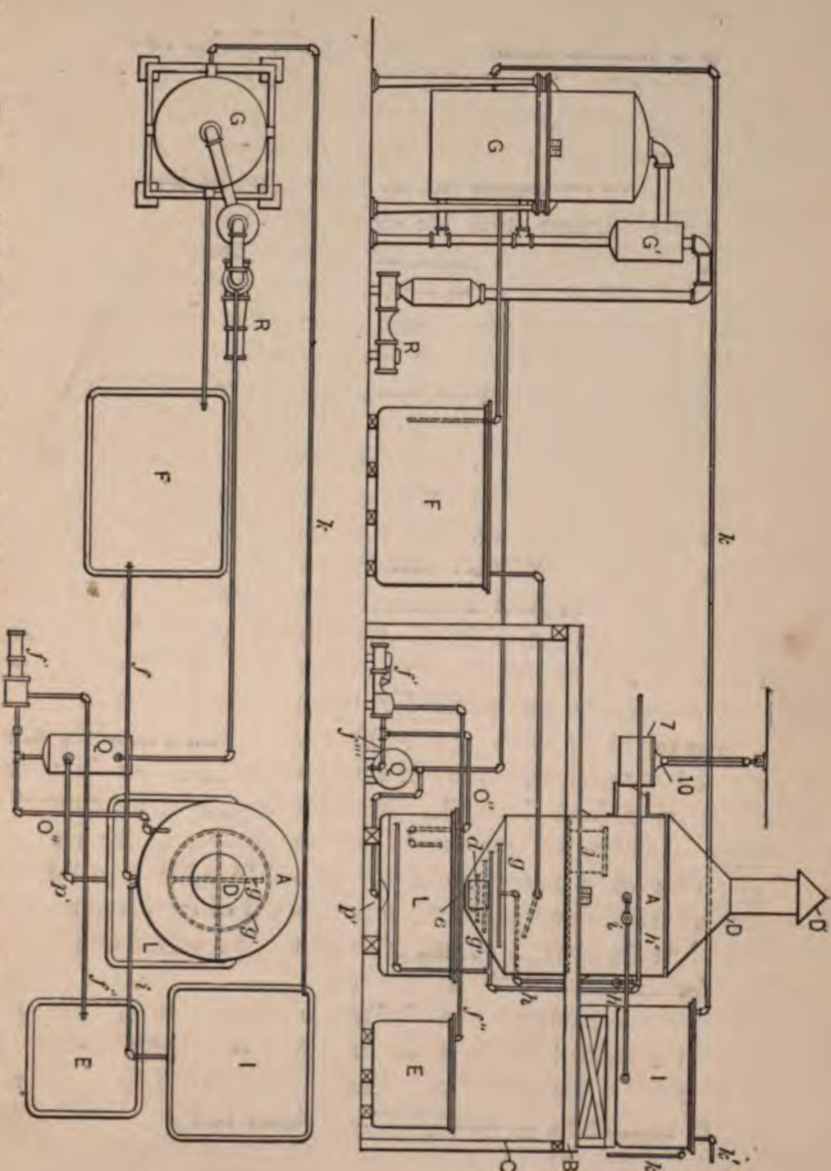


FIG. 50.—Diagram of Apparatus for the Causticization of Soda-ash and Concentration of Caustic Liquor.

or the carrier may be provided with double-flap doors 9 when it is to be used as a chute.

8 is a wheeled frame for carrying the basket or chute to the converting-kettle. In lieu of this wheeled frame an overhead tram-way may be used, as is shown in Fig. 50.

The carrier 7 is provided with suitable swivel-handles 10, by means of which the carrier can be hoisted and its contents emptied.

6 is the entrance from the lime-house to the converting-kettle.

The lime-carrier 7 is preferably made of iron or a non-inflammable material, and as the floor in front of the iron converting-kettle is bricked or covered with iron or otherwise made fireproof no danger is incurred by using this carrier in an ordinary building, thus enabling this part of the operation to be carried on in an ordinary factory building.

By the use of power the lime can be conveyed to the converting-kettle by means of any suitable endless conveyor or to any conveniently located receiver, from which it can be either by hand or automatically fed into said converting-kettles.

In Figs. 50 and 51, *A* is a converting-kettle formed of any suitable shape and with a conical, bevelled, or flat bottom, as may be desired. This kettle is supported by means of lugs from the I-beam frames *B*.

C are suitable iron pillars for supporting the beams *B*.

The top of the kettle is preferably covered with a hood *D*, formed of wood or metal, at the top of which is an exit *D′* for the passage of the steam from the kettle. Near the bottom of the converting-kettle is shown an iron door *d* for the removal of the residuum. This door when used is preferably shaped to conform to the kettle and is carried down as nearly to the bottom of the kettle as is possible. At the extreme bottom of the kettle is a valved outlet-pipe *e*, also for the removal of the residue.

f is a pipe having a pivoted elbow within the kettle, by means of which the liquid lye can be run into the receiving-tank *F*.

Located at the bottom of the kettle *A* is preferably a perforated coil of steam-pipe *g*, through which steam can be ejected for the boiling of the caustic lye, and it can also be used for producing motion of the contents of the kettle. In addition to this a closed coil of steam-pipe *g′* may be employed for heating the contents of

the converting-kettle. If the perforations in the steam-pipe *g* are placed underneath the pipe and on the sides thereof at about an angle of 45°, there will be a thorough agitation of the material, obtaining a complete conversion. The pipes *g* and *g'* are located at any suitable distance above the bottom of the kettle.

Air under pressure may be injected into the liquid, or to attain the same end a mechanical mixer or stirrer can be introduced within the kettle, the object being to maintain a constant agitation of the contents of the kettle and the complete admixture thereof. The pipes *g* and *g'* are connected with a source of steam-supply by means of the pipe *h*, having the valve *h'* therein. *h''* is the main steam-pipe, shown running across the front of the kettle. If more than

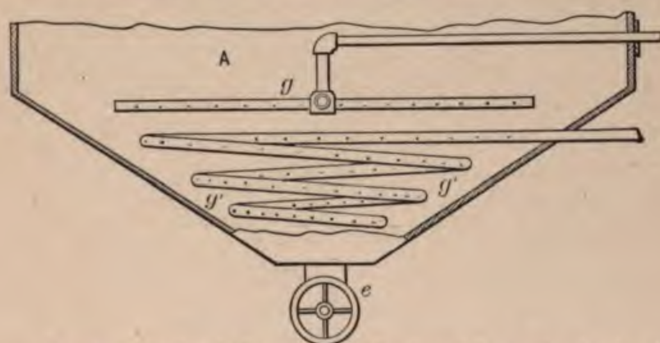


FIG. 51.—Sectional View of Lower Portion of Converting-kettle.

one kettle is used, this pipe can be extended for the supply of steam to the additional kettles.

Below the hood *D* is an opening, preferably in front, for the introduction of the ash and lime. The latter is preferably introduced in small quantities at a time into the basket *j*, which is adjacent to said opening, so located as to be partially immersed within the liquid. The entrance to the kettle is protected by a door, which being closed when not in use will prevent the outlet of the steam. As shown; the hood *D* should extend a short distance beyond the sides and over the top of the kettle, so that the draft thereby produced will facilitate the exit of the steam through the opening *D'*. The hot-water receiving-tank *I* is elevated, so that its contents can be run into the converting-kettle *A* by means of the valved pipe *i*.

This tank is supplied with hot water from the coils of the evaporator or concentrator *G* by means of the pipe *k*. If this supply is insufficient, additional water, either hot or cold, may be introduced by means of the valved pipe *k'*.

k'' is an overflow from the tank *I*.

Situated below the converting-kettle is the screen-tank *L*, into which the residue of the materials used can be emptied by means of the pipe *e* or the door *d*. This tank is preferably provided with a false suspended bottom *o* (see Fig. 52) consisting of one or more layers of canvas and wire-gauze and which is so arranged that the

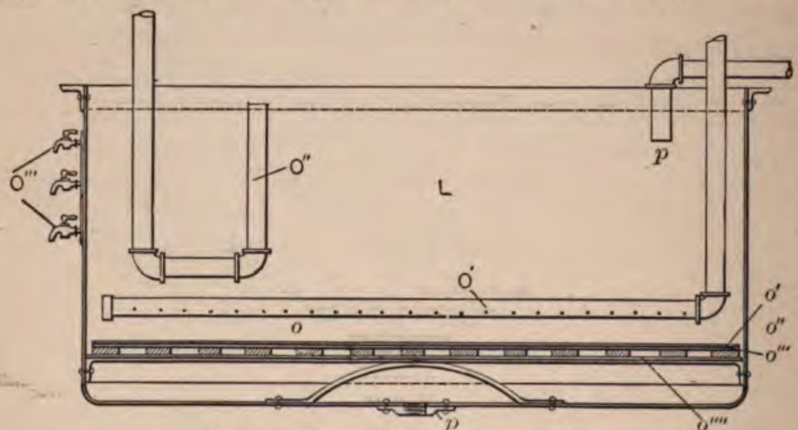


FIG. 52.—Sectional View of Screen-tank.

residue or lime-mud will not pass through the screen when operated upon by a vacuum-pump, the liquid and air passing through a pipe connecting with the bottom of the tank. This false bottom is preferably placed two or three inches above the bottom of the tank and consists, first, of a wire screen *o'* of very fine mesh, underneath which the duck or canvas *o''* is stretched. The fabric is supported, preferably, upon a sheet of gauze *o'''* of slightly coarser mesh, which in turn is supported upon an iron frame *o''''*. Within this tank, a short distance above the false bottom, is a perforated steam-pipe *O'*, the perforations of the pipe being preferably arranged underneath and on the sides thereof at an angle of about 45°.

A suitable jointed elbow *O''* is used for decanting such portion of the supernatant liquid and wash-water as settles above the residue.

O''' are faucets or cocks used for accomplishing the same purpose. A pipe p for the supply of water for the admixture and the washing from the lime-mud or residue of any caustic lye not removed in the kettle is placed at one side of the tank. Adjacent to the screen-tank L is the wash-water tank E, which is connected to said tank by means of the pipe O'', through which the wash-waters from said screen-tank can be transferred to said wash-water tank.

R is the vacuum-pump, having a connection at p' with the bottom of the screen-tank and discharging into the catch-all or tank Q, from which the wash-water can be transferred to the wash-water tank E by means of the service-pump f and pipes f'' f'''.

Procedure of Causticization.—The operation of the plant is as follows: Water is run into the converting-kettle A and brought to a boil therein, and then a given quantity of soda-ash is put into the said converting-kettle and the boiling continued till the complete dissolution of the ash, making a solution of about 12° Baumé. Then small portions of lime are added gradually through the medium of the lime-basket j, placed at a point in the converting-kettle so that such basket will be suspended partly in the liquid. The boiling (with open steam) is continued and lime added for the conversion of the soda-ash into caustic soda, which can be determined by testing in any suitable way. When the liquid is thoroughly causticized, as indicated by the suitable test referred to, the steam is shut off and the whole allowed to settle for a time, after which the clear liquid is then drawn off from the converting-kettle by means of the pipe and elbow f, either by gravity or being pumped and run to a suitable tank or other receptacle F for storing the liquor, from whence it is delivered direct to the soap-factory or refinery, or if not of sufficient density it is then run to the evaporator G, which can be of any suitable construction for concentrating it to the desired density. The eduction-pipe from this evaporator connects, preferably, with a catch-all G', by means of which moisture mechanically entrained with the vapors may be arrested and conveyed back to the evaporator. There will then remain in the converting-kettle A mud composed of calcium carbonate entangled with caustic-soda lye, which mud is drawn from the converting-kettle through either or both of the outlets e or d in the bottom of said kettle and run

into the screen-tank *L* and allowed to settle, and the liquor above the lime-mud or residue is drawn off through a suitable pipe *O''* siphonically or by means of a pump, or can be run off by gravity through an outlet or outlets *O'''* on the side of said screen-tank, and is run to the same tank *F* as the clear liquid that was previously drawn off from the converting-kettle, or if of insufficient strength it may be run to the tank or receptacle *E*. Then water is run into the screen-tank and the mass brought to a boil by the injection of steam through the perforated steam-pipe or coil, after which the mass is again allowed to settle, and the resulting clear liquid that then settles above the lime-mud is decanted or drawn off in the same manner. Then more water is added to the mud in the screen-tank and the same operation repeated until the clear liquid that settles in said tank shows "o" Baumé when tested with a regular alkali hydrometer. Then the remaining liquid with which the mud is saturated is drawn therefrom by means of applying a vacuum below the screen, the liquor being drawn by said vacuum into a suitable receiver, preferably a cylindrical vessel *Q*, and the liquor thus collected in the cylindrical vessel is then run to join the other wash-waters that have been drawn from the screen-tanks by other means. Such of these wash-waters as have been run from the screen-tank *L* to a receptacle *E*, separate from the storage-tank from which the refinery, soap-house, or evaporator is supplied, are used in the converting-kettle for dissolving the next charge of soda-ash, such water being added in addition thereto as may be required, which additional water is preferably a water of condensation from the steam-coils or heating-chamber of the evaporator, which water of condensation shall have been run to the tank *I* or other suitable receptacle.

CHAPTER VII.

COTTONSEED PRODUCTS.—*Continued.*

Refining of Crude Cottonseed-oil. The Refining-kettle. Apparatus of Refining. Use of Caustic Alkali. Procedure of Refining. Finishing Refined Oil. Influence of Heat on Refined Oil. Classification of Summer Yellow Oil. Products of Summer Yellow Oil. Bleaching Summer Yellow Oil. Winter Oils. Classification of Winter Oils. Nature and Valuation of Fullers' Earth. Press-cake. Cottonseed-oil Soap-stock. Determination of Fatty Acids, Free or Uncombined Oil, and Total Fatty Acids in Cottonseed-oil Soap-stock.

Refining of Crude Cottonseed-oil.—The necessity of working up seed promptly to avoid deterioration and subsequent impairment of the oil, the inconvenience and cost of gathering and shipping a bulky article, the greater convenience of shipping the crude oil, the necessity of the return of the by-products of oil-milling, viz., meal and hulls, to the soil that has produced the seed, the superior skill and experience, hence its scarcity, required in refining crude oil, the necessity for the fullest efficiency of operation of refining on as large a scale as is consistent with the greatest economy, represent, in so far as relates to the production of crude cottonseed-oil as a finished product, the natural gravitation of the forces of production to the source of the raw material. Hence we find in the growth of the industry a rapid multiplication of crude-oil mills in the most desirable sections of the cotton belt for the receipt of seed, by wagon, water, and rail, and likewise the establishment of refineries at centrally located points for the receipt of the crude oil by rail and for the distribution of the products of refining.

The real advancement of the last twenty years in the cottonseed-oil industry has been made by the refinery. While there have been many improvements in the machinery of the crude-oil mills, the process is to-day practically what it was many years ago, but when

we turn to the refinery, the tremendous strides which have been made in the improvement of the refining methods result in a product so superior to the article produced years ago, that industries utilizing the oil, on account of this improvement, can use greater quantities of the oil than ever before.

The Refining-kettle.—The agent used for refining is caustic soda, which is fully described in Chapter VI. The apparatus used is a plain cylindrical tank, or kettle, with conical or flat bottom, or with bottom slightly dished to facilitate removal of last traces of sediment. The kettle is provided with a swing-joint, or siphon pipe, located at a convenient level on the side of the kettle, for the decantation of the refined and settled oil. Below the swing-joint pipe and at a convenient distance from the bottom of the kettle may be another outlet to provide for a more complete separation of the oil from the sludge, or sediment. In the bottom of the kettle is a valve for the removal of the precipitate obtained on refining. The contents of the kettle may be heated by either exhaust or live steam in either open or closed coils, or both. Air for agitating the contents is introduced by means of a crisscross pipe, provided with openings, which connects with a pipe running over the side of the kettle and leading to an air-pump or compressor. Caustic soda is run into the kettle by gravity directly from the lye-tanks, where it is reduced to the required density, through a perforated pipe which distributes it uniformly over the surface of the oil.

The capacity of the refining-kettle varies, the smallest being that which will provide ample room for working and will produce of supernatant refined oil a volume at least equal to the capacity of a tank-car,* viz., 125 barrels, this being the smallest amount for profitable handling. The maximum size will be determined by facilities for heating and agitation and by results obtained with larger batches than that of a tank-car. The prime essential in refining is intimate contact of alkali and oil at the proper temperature. The crude oil may be transferred to the refining-kettle from the storage-tank either by pump, or by gravity where the arrangements of the piping system permit of the latter choice.

Apparatus of Refining.—The equipment of a refinery is most conveniently installed in a three-story and basement building.

This construction permits the handling of much of the material by gravity and the separation of different stages of the work into corresponding departments. On the third floor are located the refining-kettle and the caustic-lye tank, from which lye at the density required may flow by gravity into the refining-kettle. On the second floor are located the finishing-kettle and the bleaching-plant, and in a separate portion of the same floor, the kettle for working up the soap-stock. On the first floor are located pumps for transferring crude and refined oil, and here the products of refining are discharged into their packages. In the basement are located receiving-tanks for crude oil, into which oil may be discharged by gravity from barrels or tank-cars and from which it may be pumped as desired either into the refining-kettle or storage-tanks. The caustic melting-tank may be also located in the basement, from which the strong lye is pumped to the top floor and diluted to the density desired.

Use of Caustic Alkali.—The function of caustic soda in cottonseed-oil refining is to combine with the free fatty acid present in the crude oil as a result of the decomposition of the originally neutral oil. The product of this combination is a true soap, sodium oleate, and is the same as that which is formed when cottonseed-oil is saponified with caustic soda in soap manufacture. In the combination of free vegetable acid together with more or less oil and caustic soda, with the combined agitation and heating, the coloring-matter of the crude oil and the mucilaginous and albuminous matter unite to form a coagulum which, on allowing the treated oil to stand, settles to the bottom of the kettle together with unused alkali, which is added in excess, and more or less oil mechanically mixed. This precipitate constitutes the raw material for the commodity that comes on the market as "cottonseed-oil soap-stock."

The amount of caustic soda, both in the absolute quantity of sodium hydrate and in the volume of the solution required for refining, is subject to wide variation. A quantity of caustic-soda solution requisite to saturate the free acidity of the crude oil as ascertained by analysis, is insufficient to effect the purification desired, so an excess must be added, which must be determined by experiment with a sample of the crude oil. The percentage of free fatty

acids will vary from 0.4 per cent. to as high as 30 per cent., but the average is in the neighborhood of 2 per cent. The free acidity is estimated in terms of oleic acid, $C_{18}H_{34}O_2$, molecular weight 282. If in a batch of crude oil weighing 50,000 pounds, the free fatty acid content is found to be 2.5 per cent., the weight of free oleic acid is, therefore, 1250 pounds. One molecule of oleic acid combines with one molecule of sodium hydrate, NaOH, molecular weight 40; therefore, according to the following equation:

Oleic acid (282) : Sodium hydrate (40) :: 1250 pounds : x;

x, the weight of sodium hydrate required for neutralization, equals 177.3 pounds. This weight of chemically pure caustic, expressed in terms of the commercial grade of 74°, which contains but 95.48 per cent. of available caustic, equals 185.7 pounds, which is approximately the weight contained in an equivalent number of gallons of caustic-soda solution of 15° Bé. made from 74° caustic.

The percentage of caustic-soda solution of the density desired is arrived at by refining-tests on samples, using solutions of different strengths and proportions, until the results desired on a practical scale are obtained with the sample.

According to the character of the oil the density may vary from 6° Bé. to 25° Bé., with the percentage of the solution necessary in inverse proportion to its density. It is necessary that the alkali be uniformly distributed over the surface of the oil, which is effected by means of the spray-pipe previously mentioned, and that during the addition the oil be kept in agitation, without which precaution the caustic-soda solution, in virtue of its greater density, would sink at once to the bottom, and intimate contact with the oil would then be difficult to attain.

Procedure of Refining.—After the batch of crude oil has been accurately weighed and a sample taken for the refining-test, it is transferred to the refining-kettle, which has previously been thoroughly cleaned. The methods of manipulation vary greatly with individual refiners. By some the oil is first heated to 85° Fahr., when caustic-soda solution of required quantity and strength is added, meanwhile keeping up vigorous agitation; the more quickly the caustic is added the better. After the addition of the solution,

TABLE 10.—SPECIFIC GRAVITY OF SOLUTIONS OF PURE CAUSTIC SODA AT 15° C. (59° F.). (LUNGE.)

Specific Gravity.	Degrees Bé.	Degrees Twaddell.	Per Cent. Actual Alkali Na_2O.	Per Cent. Caustic NaOH.	1 Liter Contains Grams.		1 Gal. (231 Cu. In.) Contains Av. Ozs.	
					Actual Alkali Na_2O.	Caustic Soda NaOH.	Actual Alkali Na_2O.	Caustic Soda NaOH.
1.007	1	1.4	0.47	0.61	4.	6.	.53	.80
1.014	2	2.8	0.93	1.20	9.	12.	1.20	1.60
1.022	3	4.4	1.55	2.00	16.	21.	2.13	2.80
1.029	4	5.8	2.10	2.71	22.	28.	2.93	3.73
1.036	5	7.2	2.60	3.35	27.	35.	3.60	4.67
1.045	6	9.0	3.10	4.00	32.	42.	4.27	5.60
1.052	7	10.4	3.60	4.64	38.	49.	5 07	6.54
1.060	8	12.0	4.10	5.29	43.	56.	5.74	7.47
1.067	9	13.4	4.55	5.87	49.	63.	6.54	8.41
1.075	10	15.0	5.08	6.55	55.	70.	7.34	9.34
1.083	11	16.6	5.67	7.31	61.	79.	8.14	10.54
1.091	12	18.2	6.20	8.00	68.	87.	9.07	11.61
1.100	13	20.0	6.73	8.68	74.	95.	9.87	12.66
1.108	14	21.6	7.30	9.42	81.	104.	10.81	13.87
1.116	15	23.2	7.80	10.06	87.	112.	11.61	14.94
1.125	16	25.0	8.50	10.97	96.	123.	12.81	16.41
1.134	17	26.8	9.18	11.84	104.	134.	13.87	17.88
1.142	18	28.4	9.80	12.64	112.	144.	14.94	19.21
1.152	19	30.4	10.50	13.55	121.	156.	16.14	20.81
1.162	20	32.4	11.14	14.37	129.	167.	17.21	22.28
1.171	21	34.4	11.73	15.13	137.	177.	18.28	23.62
1.180	22	36.0	12.33	15.91	146.	188.	19.48	25.08
1.190	23	38.0	13.00	16.77	155.	200.	20.68	26.68
1.200	24	40.0	13.70	17.67	164.	212.	21.88	28.29
1.210	25	42.0	14.40	18.58	174.	225.	23.22	30.02
1 220	26	44.0	15.18	19.58	185.	239.	24.68	31.89
1.231	27	46.2	15.96	20.59	196.	253.	26.15	33.76
1.241	28	48.2	16.76	21.42	208.	266.	27.75	35.49
1.252	29	50.4	17.55	22.64	220.	283.	29.35	37.76
1.263	30	52.6	18.35	23.67	232.	299.	30.95	39.89
1.274	31	54.8	19.23	24.81	245.	316.	32.69	42.16
1.285	32	57.0	20.00	25.80	257.	332.	34.29	44.30
1.297	33	59.4	20.80	26.83	270.	348.	36.02	46.43
1.308	34	61.6	21.55	27.80	282.	364.	37.66	48.57
1.320	35	64.0	22.35	28.83	295.	381.	39.36	50.83
1.332	36	66.4	23.20	29.93	309.	399.	41.23	53.24
1.345	37	69.0	24.20	31.22	326.	420.	43.50	56.04
1.357	38	71.4	25.17	32.47	342.	441.	45.63	58.84
1.370	39	74.0	26.12	33.69	359.	462.	47.90	61.64
1.383	40	76.6	27.10	34.96	375.	483.	50.03	64.44

TABLE 10.—*Continued.*

Specific Gravity.	Degrees Bé.	Degrees Twaddell.	Per Cent. Actual Alkali Na_2O.	Per Cent. Caustic NaOH.	1 Liter Contains Grams.		1 Gal. (231 Cu. In.) Contains Av. Ozs.	
					Actual Alkali Na_2O.	Caustic Soda NaOH.	Actual Alkali Na_2O.	Caustic Soda NaOH.
1.397	41	79.4	28.10	36.25	392.	506.	52.30	67.51
1.410	42	82.0	29.05	37.47	410.	528.	54.70	70.45
1.424	43	84.8	30.08	38.80	428.	553.	57.11	73.78
1.438	44	87.6	31.00	39.99	446.	575.	59.51	76.72
1.453	45	90.6	32.10	41.41	466.	602.	62.18	80.32
1.468	46	93.6	33.20	42.83	487.	629.	64.98	83.92
1.483	47	96.6	34.40	44.38	510.	658.	68.05	87.79
1.498	48	99.6	35.70	46.15	535.	691.	71.38	92.20
1.514	49	102.8	36.90	47.60	559.	721.	74.58	96.20
1.530	50	106.0	38.00	49.02	581.	750.	77.52	100.07

continue agitation for about ten minutes. Then heat gently with moderate agitation to about 125° Fahr. The time required from the addition of the caustic-soda solution to the maximum temperature of 125° Fahr. should be at least fifteen minutes. There is no objection to longer time being used. Agitation should be continued gently until there is a disposition on the part of the impurities to curdle. By other refiners, the oil and alkali are first agitated in the cold until perfect admixture is obtained. This may require from fifteen to twenty-five minutes. When the body of the oil has assumed an almost black color, heat is applied gently, with continued agitation, until the oil is about 125° Fahr. This treatment is continued until the physical appearance noted above is observed, viz., the separation of impurities as dark-brown flakes, and a general curdled appearance. The attainment of the maximum temperature, 125° Fahr., should be very carefully watched; 130° Fahr. is not dangerous, and good oil should never go above 140° Fahr. At this stage of the process, samples should be taken from time to time and filtered through filter-paper. The progress of the purification may thus be observed in the successive filtrates. When the desired results in color, odor, and clearness are exhibited by the samples, agitation and heating are discontinued. The contents of the kettle are now allowed to stand to await the precipitation of the excess of alkali and the impurities which constitute the raw soap-stock. After the

settling period, which requires as a rule from three to five hours, the supernatant oil has assumed a bright-yellow color and is ready to be transferred to the "finishing" tank by means of the swing-joint pipe previously described. This pipe may be lowered at will in the kettle and the oil drawn off as close to the settlings as desired. The quantity of oil that can be removed depends upon the amount of the precipitate and the thoroughness of the settling.

Finishing Refined Oil.—The treatment of the yellow oil in the finishing-tank is for the purpose of washing out the excess of alkali added in the refining-kettle and to eliminate the last traces of water. If the amount of alkali retained is slight, one washing may suffice to remove it. The temperature should not exceed 100° to 105° Fahr. The fittings of the finishing-tank are similar to those of the refining-kettle. The wash-water should be uniformly distributed over the surface of the oil, agitation continuing meanwhile. After settling the wash-water is withdrawn from the bottom until the clear oil comes. The washing should be repeated in this manner until the last traces of alkali are removed. Where a considerable excess of caustic-soda solution has been added in the refining-kettle, much trouble may be experienced in its complete elimination. The use of pickle or brine of not greater density than 10° Bé. is recommended in obstinate cases. The greater density of the pickle-wash not only facilitates settling, but imparts an agreeable taste to the oil. After all traces of alkali have been satisfactorily removed, the final treatment of the oil is for the elimination of water. During the preliminary washing, the temperature should not exceed 100° to 105° Fahr. The oil is now heated gently, with continued agitation, to a temperature not exceeding 125° Fahr. With a considerable quantity of moisture present, it is frequently advisable when removing the settlings to run off a portion of the cloudy oil and continue the drying of this portion in a separate tank, thereby making easier the elimination of the reduced proportion of moisture in the larger body of oil. After the process of drying has been conducted for some time the oil is finally dried by the addition of varying amounts of plaster of Paris, the amount being determined by the amount of water remaining. The determination is best made by taking small samples of the oil during agitation and filtering it in the labo-

ratory. After agitation with the plaster of Paris until it has been thoroughly mixed with the oil, it is filter-pressed. Oil flowing from the filter-press after the foregoing treatment has been followed should be ready for barrelling as prime summer yellow when made from prime crude.

Influence of Heat on Refined Oil.—The effect of the combined action of heat, moisture, and air on the quality of crude oil has been already dwelt upon. These three agents of decomposition are likewise to be considered in the finishing of refined oil. It is desired to expel the remaining traces of moisture at the lowest possible temperature. Excessive heat, i.e., above 125° Fahr., effects deleteriously the flavor of the oil, and at 140° Fahr., according to conditions, decomposition becomes more or less active. With "off" oil where the desideratum is the color and not the flavor, temperatures as high as 160° to 170° Fahr. are more advantageous than otherwise, as with such heat brightness of color is more easily obtainable. With crude oil of superior quality, treatment should be effected at the lowest possible temperature; below 100° Fahr., if practicable, and in the finishing-tank agitation alone should be depended upon to eliminate the last traces of moisture. The injurious influence of heat on the flavor of oil should encourage as little dependence as is practicable upon this agent for the separation of moisture. To this end it may be desirable to have the finishing-tank shallow in order to facilitate the separation.

Classification of Summer Yellow Oil.—Owing to deterioration of the seed and to varying skill of manufacture, all crude oil does not produce yellow oil of the same grade. The loss on refining crude oil depends upon its age, whether it has undergone much or little decomposition, and upon its degree of contamination with the albuminous matter of the seed. It may vary from 5 per cent. with prime crude oil to 25 per cent. and more with very inferior oil. Summer yellow cottonseed-oil is classed and graded as follows:

Prime summer yellow must be clear, sweet in flavor and odor, free from water and settlings, and of no deeper color than 35 yellow and 7.1 red on Lovibond's equivalent color scale. If the oil is of deeper color than the glass standard (35 yellow, 7.1 red) it shall not be prime.

Choice summer yellow must be sweet in flavor and odor, clear and brilliant in appearance and free from moisture.

Off summer yellow shall be free from water and settlings, off in taste and color and should be sold by sample.

The proportion of the different grades of summer oil produced depends upon the quality of the crude oil and this in turn is determined by the quality of the seed. It has varied from about 85 per cent. to 35 per cent. of prime and choice oils, and from 15 per cent. to 65 per cent. of off oil. In the treatment of summer oil, the loss in transforming the product into a superior grade is very slight.

Products of Summer Yellow Oil.—Summer white oil is obtained from summer yellow oil by bleaching with fullers' earth and filtering, and is used chiefly in the manufacture of lard compound. Winter yellow and winter white oils are obtained from the corresponding grades of summer yellow and summer white oils by the separation of the solid glycerides at reduced temperature. The solid glycerides constitute commercial cotton-oil stearin which is used in the manufacture of lard compound. The winter oils remain limpid at 32° Fahr. and are marketed directly as salad- and cooking-oils, and indirectly as butter substitute, of which they form a varying ingredient. Miners' oil, a product of very limited application, is a winter oil obtained from off summer yellow. It early replaced lard-oil as an illuminant for miners' use, and soon, for the same purpose, came to be adulterated with petroleum distillate. The separation of the solid glycerides corrects the tendency of the oil to smoke.

Bleaching Summer Yellow Oil.—The apparatus required for this purpose comprises essentially a storage-tank for the summer yellow oil, a bleaching-kettle, a storage-tank for the filtrate, or summer white oil, a filter-press, a feed-pump for the press, and necessary pipe and valve connections for oil and steam. The finishing-kettle may serve as a storage-tank. The filter-press is similar in construction and operation to that used for clarifying crude oils. The bleaching agent is fullers' earth. Bleaching consists in agitating the oil with a requisite amount of fullers' earth and filtering the mixture. Agitation may be effected either by means of air, as in the refining-kettle, or by means of a vertical shaft carrying horizontally inserted arms, or blades. For the complete removal of

the coloring-matter, it should be endeavored to obtain the most intimate admixture of the oil with the absorbent earth. In Fig. 53 is shown a plan of a bleaching plant adapted for the bleaching of either tallow and grease or oil. Sulphuric acid alone, or in conjunction

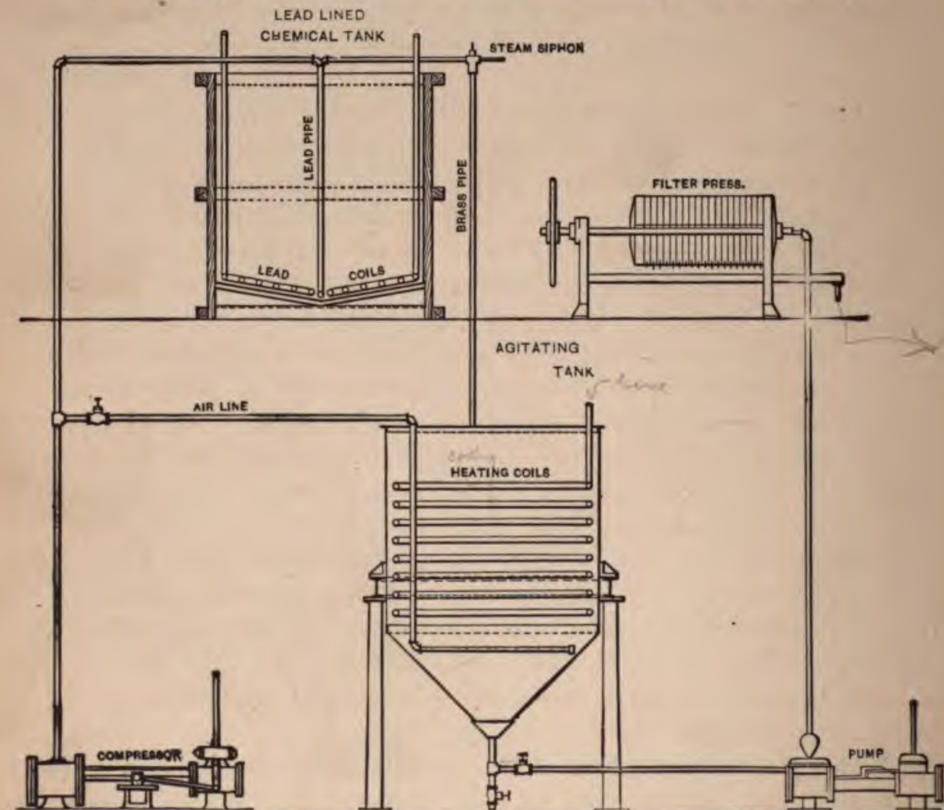


FIG. 53.—Bleaching Plant.

with bichromate of soda, may be used in addition to the fullers'-earth treatment for animal fats. For vegetable oils the fullers'-earth treatment suffices. A plant of the same description may also be used for the preparation of miners' oil from off summer yellow oil. Sulphuric acid effects decolorization by dehydrating or charring the organic coloring-matter, thus facilitating its removal. In the procedure of bleaching with fullers' earth, summer yellow oil is transferred to the bleaching-kettle and fullers' earth added. The

proportion of earth to oil varies greatly according to quality of the oil and earth and skill of the refiner. Agitation having begun and a known weight of earth added, samples are taken from time to time and filtered through filter-paper into a four-ounce oil sample bottle. More earth is added as required to produce the desired brightness of color in the sample. When this has been obtained the mixed earth and oil are filtered, the first runnings from the press being returned to the bleaching-tank until the oil flows clear and brilliant. The proportion of earth used amounts to from 2 to 5 per cent. of the weight of oil. The least amount of earth necessary should be used, as its contact with the oil impairs the flavor. To produce the best results only choice summer yellow oil should be treated. The flavor imparted by fullers' earth may be neutralized by the addition of from 1 to 2 per cent. of soda-ash before filtration.

Winter Oils.—As the temperature is reduced, the glycerides of higher melting-point crystallize out of the liquid portion of the oil. Advantage is taken of this difference in melting-point to separate the more readily congealing portion with the result that oil is obtained which will remain fluid at the freezing-point of water. The temperature at which the more solid glycerides crystallize depends upon the quality of the oil; oils containing a considerable proportion of stearin and palmitin will begin to crystallize at a higher temperature than those containing less. Summer oils will begin to crystallize from 50° to 35° Fahr. This is shown first by a slight turbidity, which increases as the temperature falls until the oil becomes firm at 32° Fahr.

The practical separation of the portions of cottonseed-oil, respectively solid and liquid, at 32° Fahr., is carried out after the manner in which edible tallow is resolved into oleo-stearin and oleo-oil, with the exception that a much lower temperature of manipulation and pressing is necessary. This involves the installation of refrigerating-machinery, that a suitably low temperature may be maintained for the crystallization of the oil and its subsequent treatment. The procedure of separation comprises essentially the storage of the oil in shallow trays in the cooling-room until the crystallization, or "seeding," of the oil is effected. When sufficiently cooled, the oil is in the shape of a cake corresponding to the dimensions of the

tray. The individual cakes are transferred to cloths, carefully wrapped and piled between metal plates in a press. On application of pressure, the liquid portion of the oil, consisting of olein, is expelled, while the solid portion, consisting of stearin and palmitin, remains to form the cake. The cake goes into lard compound, while the oil finds rapidly extending use as a salad-oil and in the packing of sardines.

As the products of crude cottonseed-oil are increased in purity by successive processes, increased skill and capital become necessary. As a result, the establishments producing the refined grades are few in number.

Classification of Winter Oils.—Different grades of summer oils produce corresponding grades of winter oils. According to the rules regulating transactions in cottonseed-oil among members of the New York Produce Exchange, two chief grades are recognized as follows:

Winter white cottonseed-oil, to pass as prime, must be straw-white to white in color, brilliant, sweet in flavor and odor, and must stand limpid at a temperature of 32° Fahr. for five hours.

Winter yellow cottonseed-oil, to pass as prime, must be brilliant, free from water and settlings, sweet in flavor and odor, of straw color (not reddish), and must stand limpid at a temperature of 32° Fahr. for five hours.

According to the same rules, tests for winter cottonseed-oil shall be made as follows: A regular 4-ounce sample bottle shall be filled full of the oil to be tested; a thermometer shall be inserted through the cork of the bottle, and the bottle hermetically sealed. The oil shall then be heated slowly to a temperature not exceeding 80° Fahr., and remain at that temperature not exceeding fifteen minutes. It shall then be chilled until it stands at 32° Fahr., at which point it must stand for five hours, and must be clear, brilliant, and limpid at the expiration of that time.

Nature and Valuation of Fullers' Earth.—Agitation with fullers' earth and filtration is the almost universal method for the clarification of oils. Originally, all the fullers' earth used in the United States was imported chiefly from England, but in recent years deposits of very good quality of earth have been discovered and are

being worked in this country. The color, taste, physical condition, or chemical analysis does not determine the value of this body for bleaching purposes. This can be determined with certainty only by practical experiment with the oil to be bleached. When dry it adheres strongly to the tongue, but many clays, with which it may be regarded as of similar character, do the same. Unlike clay, it lacks plasticity; it has a high percentage of combined water, and a content of alumina rarely exceeding 15 per cent. Its natural color varies from brown, gray, to dark blue, due to the presence of organic matter. Fullers' earth was originally used for cleansing cloth of grease and also by furriers for cleaning furs. Its chief physical characteristics are its fine grain, non-plasticity, and that when thrown into water and broken up, it forms a somewhat flocculent mass. Its commercial value resides in its high absorbent and decolorizing power. In its preparation for market, the usual method, after mining, is to spread the material in a thin layer over a drying-floor, although a more modern method is to heat it by fire in cylinder dryers. Before putting it through the dryers, it is first pulverized. In drying it assumes a white color and parts with upwards of 60 per cent. of moisture. It is then sieved into various degrees of firmness, usually 100 or 120 mesh, and put in bags for shipment.

Press-cake.—The residue left in the filter-press and forming the cake is fullers' earth plus absorbed organic matter, with more or less retained oil. The quantity of the latter may be reduced to a minimum by steaming out the press. The disposition of the oil thus separated by steam will be determined by its quantity and quality. The oil yet remaining in the cake, while of considerable amount in the long run, is valueless considering the expense of its recovery. The press-cake is a worthless by-product.

Cottonseed-oil Soap-stock.—The sludge remaining in the refining-kettle after the removal of the supernatant yellow oil for treatment in the finishing-kettle, consists of neutral oil, caustic soda, soda-soap of oleic acid, together with coloring-matter of the seed and albuminous and mucilaginous matter which constitute a considerable proportion and the most offensive part of the loss on refining. This mass contains the material which, disseminated in suspension and

solution in the crude oil, supplies the cause for the decomposition and deterioration of the neutral oil. It is dark in color, of offensive odor, and exceedingly troublesome to handle. On exposure to air oxidation with decomposition of the unstable albuminoids ensues rapidly.

A more complete separation of the mechanically mixed oil is effected by transferring the raw soap-stock to a tank reserved for this purpose, where it is again heated up to allow the good oil to rise to the surface, whence it is skimmed off to be reworked with a subsequent batch of crude oil. The material may then be run into suitable packages and disposed of in its original untreated form, or put through a process of purification whereby practically all of the non-oleaginous matter is separated.

If purified, the raw stuff is transferred to a kettle especially reserved for this purpose and allowed to accumulate in sufficient amount for treatment. The procedure of the purification of this material is practically that of soap manufacture. The nature of its utilization will depend largely upon manufacturing conditions at the place of its production. If a soap-factory is operated in connection with the refinery, it may be transferred thence and its manipulation become part of the technical procedure of that department. If sold in a purified form to soap manufacturers it is treated at the refinery and forms a commercial by-product of that enterprise.

According to rules governing transactions in cottonseed products all sales of raw soap-stock, unless otherwise agreed upon by buyer and seller, are sold upon a basis of 50 per cent. fatty acid, not to fall below 40 per cent. If containing less than 40 per cent. fatty acid soap-stock shall not be considered merchantable. Delivery to be made in iron-bound hardwood packages or tank-cars.

A contract tank-car of soap-stock shall be 50,000 pounds unless otherwise specified.

The crude soap-stock is similar in its character to the "nigre" of the soap industry; the former is the concentrated impurities of the crude oil, containing more or less oil according to the completeness of its separation; the latter is soap containing the impurities, with much water, that have settled out during the period of cooling that a boiling of soap undergoes preparatory to crutching and fram-

ing. To utilize the nigre after the supernatant pure soap has been crutched and framed, it is boiled up and grained with dry salt and the impurities and coloring-matter precipitated into the sub-lye. This is run into the sewer and the grained nigre is ready to be used in subsequent boilings of soap.

Where it is desired to transform the crude soap-stock at once into a merchantable article it is boiled up with the excess of alkali left on refining. The alkali is absorbed, leaving an excess of free oil. When absorption is complete, as determined by the taste, dry salt is added in sufficient quantity to give the soap a good, close grain, and the contents of the kettle are allowed to stand. The very impure and foul sub-lye is discharged into the sewer. Water is now added to the kettle, which should be boiling gently, until the soap is closed. The soap is again grained as before and the sub-lye run off. This washing process is repeated until the desired brightness of color is obtained. When this condition is reached the soap may be brought to a coarse finish and run directly from the kettle into suitable packages; or it may be allowed to cool after the manner of ordinary settled soap to allow impurities to settle into the nigre, after which this good soap is barrelled, and the nigre boiled up and grained for reworking in subsequent batches as described before. The soap thus obtained is firm, brown to yellow in color according to the degree of purification, and contains more or less unsaponified oil. The odor, while not offensive, is characteristic and persistent, which, with the color, gives unmistakable evidence of its origin in all detergent products made from it.

The utilization of this material for soap manufacture, either alone or in admixture with varying proportions of off summer yellow cottonseed-oil, tallow or grease, and rosin, involves its complete saponification. This treatment of the subject is reserved for the section dealing with the use of cottonseed products in soap manufacture.

Determination of Fatty Acids in Cottonseed-oil Soap-stock.—About 10 grams of the sample, more or less, according to the amount of moisture present, are weighed out into a beaker of convenient size and dissolved in the least amount of hot water necessary to effect solution. Run in slowly, stirring meanwhile, mineral acid,

either hydrochloric or sulphuric, until an excess is present. The beaker with contents is now transferred to a water-bath and heated until the liberated fatty acids have melted. The contents are now washed into a large test-tube and the whole placed in a refrigerator to cool. The fatty acids collect on the surface and solidify in the form of a cake. The cake, with all traces of fatty matter adhering to the sides of the tube, is transferred to a weighed filter and the whole weighed. The weight of fatty acids divided by the weight of soap-stock taken, gives the percentage of fatty acids in the soap-stock. The free or uncombined oil present in the soap-stock remains with the fatty acids liberated from the soap and is weighed with them. This method, while not analytically accurate, suffices for technical purposes.

Determination of Free or Uncombined Oil in Soap-stock.—About 10 grams of the sample, more or less, according to the amount of moisture present, are weighed out into an Erlenmeyer flask and dried. When the sample is sufficiently dry, the flask is cooled and a quantity of petroleum-ether (of a quality that leaves no residue on evaporation), sufficient for extraction, is added. A return-flow condenser is inserted in the mouth of the Erlenmeyer flask and the whole transferred to a water-bath and heated until extraction is complete. The extract is then separated from solid matter by filtering through filter-paper, with repeated washing with petroleum-ether to insure complete separation of the oil, into a weighed beaker. The filtrate is evaporated to dryness on the water-bath and the residue weighed. This weight divided by the weight of the sample gives the percentage of free, or uncombined oil.

Determination of Total Fatty Acids in Soap-stock.—To ascertain the percentage of fatty acids from both soap and oil, it is necessary to complete the saponification of the oil in the sample with alcoholic potash solution. To the weighed sample in an Erlenmeyer flask, alcoholic potash solution is added in quantity sufficient to complete the saponification of the free oil; a return-flow condenser is inserted in the mouth of the flask and the whole heated, with occasional stirring, until the soap formed is dissolved. The condenser is then removed and alcohol expelled by boiling. The total fatty acids are now set free, and washed and weighed as previously described.

CHAPTER VIII.

COTTONSEED PRODUCTS (Continued).

Cottonseed-oil Cake. Classification. Trimming Cottonseed-oil Cake. Cottonseed-meal. Cake and Meal and its Proper Handling. Yield of Cake and Meal. Classification. Composition. Quality and Grading of Cottonseed-meal. Uses. Determination of Oil in Cottonseed-oil Cake. Cottonseed-hulls. Uses. Cottonseed-hull Ashes.

Cottonseed-oil Cake.—On the release of pressure and the descent of the ram of the hydraulic press, the cakes, still retaining the heat imparted during cooking, are ready for removal. They are transferred quickly to the "stripping-table," where "strippers" separate the press-cloths, which are handed at once to the attendants at the cake-former for use again. The hot cakes, firm as a board, are loaded upon trucks and taken to the storage-room, where they are allowed to remain until cold. A record of the approximate weight of seed crushed may be kept by multiplying the weight of cake by two, to which sum is added the weight of oil expressed.

The appearance of the cake indicates the thoroughness of cooking and the degree of moisture left in the cake. Insufficient cooking, leaving thereby an excess of moisture in the meats, causes the cake to "creep" in the press. This condition may also be caused by too rapid travel of the ram during the application of low pressure to the press. Ends of the cake should be soft. They carry upwards of 30 per cent. of oil, which is recovered in trimming. Hard ends are the result of "creeping," and cause interior portions of the cake to retain much oil. Thorough cooking, the formation of a cake of uniform density and thickness, the wrapping of the same in press-cloth so that no unevenness is produced, and the proper application of low and high pressure, produce a cake from which the press-cloth is easily separated and which contains, after recovery of oil from the trimmed ends, the minimum percentage of residual oil.

Classification.—According to the rules governing transactions in cottonseed products, cottonseed-oil cake is graded and classed as follows:

Choice cake must be bright yellow in color, sweet in odor, soft and friable in texture, not burnt in cooking, free from excess of hulls, and must produce, when properly ground, a bright meal of deep-canary color.

Prime cake must be of good color, yellowish, not brown or reddish, sweet in odor, firm but not flinty in texture, free from excess of hulls, and must produce, when properly ground, a prime meal.

Off cake comprises all grades of cottonseed-cake which are distinctly off in color, taste, or odor, or which have been improperly manufactured, so as to incorporate in it a very large percentage of lint and hulls, or to produce an exceedingly hard, flinty texture.

Cottonseed-cake, unless otherwise specified, shall be packed in good, strong, sound Dundee bags, either new or second-hand, at the option of the seller, unless specified in contract. Packages must be well sewed and in good shipping order and bear a shipping-mark or a brand.

Trimming Cottonseed-oil Cake.—The soft ends of the cake contain over twice as much oil as the body of the cake. Inasmuch as the value of cottonseed-meal for feeding purposes lies primarily in the protein content and not in the oil, the value of the cake is not deteriorated by its removal. The recovery of the excessive percentage of oil from this portion of the cake conduces to efficiency of operation by increasing the yield of oil, and as its removal proportionately increases the percentage of protein in the cake remaining, the value of the cake is improved rather than otherwise. A form of automatic cake-trimmer adapted for use in cottonseed-oil mills is shown in Fig. 54.

The trimmer has a capacity of 21 cakes per minute. The cakes are piled on the feed-table of the machine, shown empty in Fig. 54, and are automatically trimmed, one at a time, and automatically repiled on the receiving-table, shown partly filled. As the stripper is expected to pile the cake on the machine, the requirements for extra labor practically disappear. The cakes are trimmed by passing between two cutters on opposite sides of the machine, which

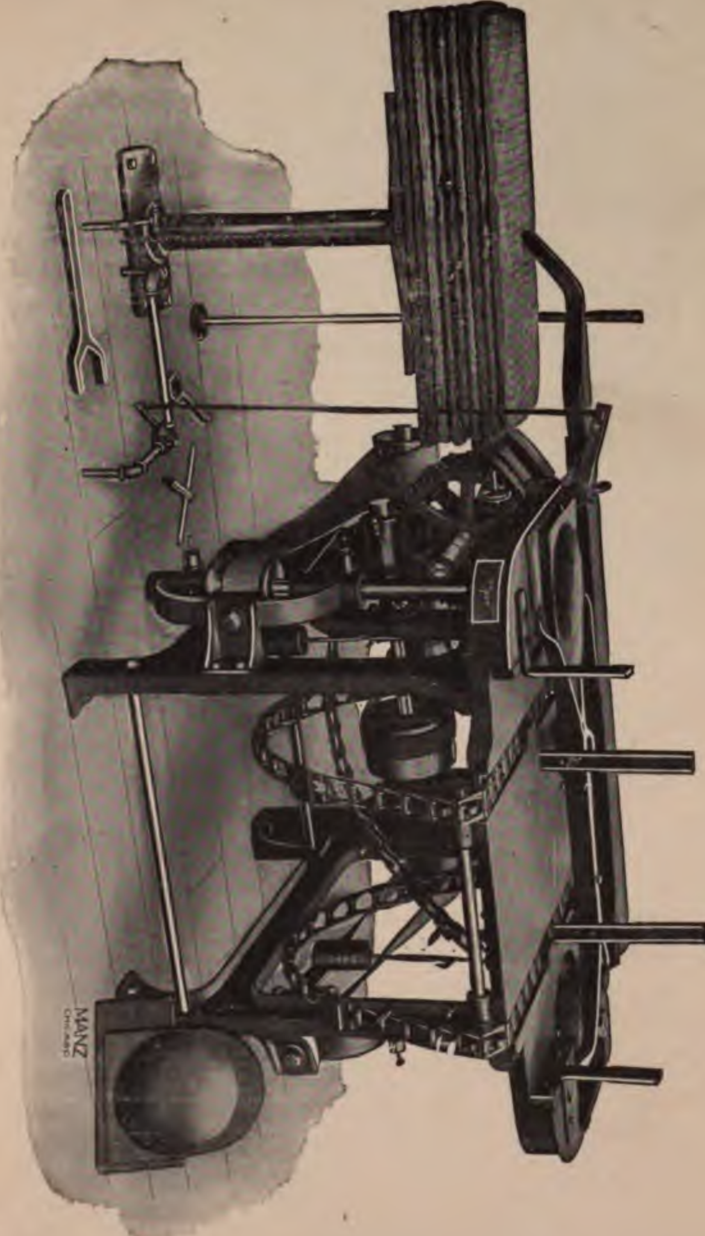


FIG. 54.—Automatic Cake-trimmer.

are free to separate as required by the individual cake passing between them. These cutters are held against the cake by tension weights, which may be increased or diminished according to the closeness of trimming required. As the cake passes between them the resistance due to its hardness spreads the cutters, which thus remove the softer portions of the cake, leaving the hard undisturbed. In this way each individual cake is trimmed, irrespective of its length, shape of its ends, or the amount of oil carried by it.

The receiving-table lowers itself automatically by the thickness of each cake as it is delivered by the trimmer. Thirty to forty cakes may be piled upon it before it is necessary to remove them and to raise the table to its former position. The table is mounted on the upper end of a vertical plunger, working in a hydraulic cylinder extending through the floor, and is raised by water or oil pressure taken from piping carrying pressures from 40 to 4000 pounds per square inch.

The meal removed from the cake, which is very fine, passes through openings in the feed-table and may be returned directly to the kettle by spouting and conveyors. Each trimmer with receiving-table requires a floor space of about $6'.8 \times 5'.3$. Two or three horse-power is the estimated requirement for the machine.

The abraded ends of the cake are worked over with fresh meats in the cooker. As they are considerably dryer the addition of more or less water is required for their proper reduction. The proportion of cake-ends and meats must be determined by the judgment of the cook.

Cottonseed-meal.—When ready for reduction, the cool and dry cakes are fed into a cake-breaker, a form of which is shown in Figs. 55 and 56. The cake is discharged from the breaker in small fragments, which are fed directly into the mill (Fig. 57). In mills of this type, which mark a great improvement over the old buhr-mill, reduction to powder or meal is effected by attrition. An attrition mill consists essentially of two upright reducing discs or plates, both of which revolve, one in opposite direction from the other. The material to be reduced is fed regularly from a hopper on top of the mill into the centre or eye of one of the discs and is thrown back and forth against the surfaces. The particles of cake, treated

in this way and by contact with themselves, are quickly reduced to meal of any degree of fineness desired.

Cake and Meal and its Proper Handling.—First I would say: * Prepare and cook your meal well. Cooking meal properly is absolutely necessary in order to get a bright firm cake. Too much attention cannot be given the cooking of the meal, and my experience has taught me to judge the meal whether cooked properly or not by the condition of the cake when taken from the presses. If the cakes are very dark and while being pressed a great deal of the meal slips, or crawls out of the presses, it is evident that there is too much moisture in the meal, or it is too "green," i.e., not cooked enough. Such cake when cool is very hard and of dark color, will stick together in the stacks, and is hard to break. Increased power on the cake-mill to grind is necessary, and with this kind of cake the superintendent cannot turn out prime meal, therefore causing a loss to the mill. On the other hand, say you are working dry seed; the raw meal as a result is very dry; the cook perhaps has the steam-pressure on the heaters too high and holds the meal in the heaters too long, not using any moisture; the result is the cake will be troublesome to get in the presses. The meal being dry and spongy, the former does not press the cakes small enough to let them go in the press-boxes with ease, so there is a hardship on the panman; after the pressure is put on them they will hang and stick to the boxes and break and scatter on the floor and perhaps you will not get one whole cake out of a pressing; the loss in this cake is greater than in the other; the yield of oil is less and both the cake and oil are scorched, rendering them both of off quality, besides the large per cent of oil left in the cake.

The necessity of proper cooking to make a prime cake is thus apparent; therefore see to it that your cook gets his meal right; also see that the former-man keeps his former in good trim; have him keep the meal-carriage cleaned out; also the tray, so the former will make a uniform cake of even density, thereby saving your press-boxes from being sprung out of shape and making a good solid,

* A paper prepared by J. P. Bass, Morgan, Texas, and J. H. Settle, Denton, Texas, read before Oil-mill Superintendents' Association, Sherman, Texas, May 27, 28, 29, 1903.

firm cake from end to end. After the proper amount of pressure is put on them there is not left in them more than seven or eight per cent. of oil; they will slip out of the presses easily and the cloths will strip off easily, thereby making a saving in the press-cloth expense.

Have the cake-stripper to handle the cakes carefully to avoid breaking them; it is a nuisance to handle broken cake; it is a loss of time and unnecessary work. By careful handling from the presses to the stacks you can avoid having so many pieces or scrap cake that take up so much space in the cake-room and consume so much time in handling; besides, it is often that a nut, small bolt, or a piece of iron of some kind will get in the scrap-pile of cake and be fed into the cake-mill, thereby breaking or gapping the grinding-plates.

The demand for broken cake or cake sacked from the breaker is increasing every year. Feeders prefer it to meal, especially for their stock cattle, as it is less trouble and expense, they not having to build troughs to feed in, but simply scatter the broken cake on the ground; so for that class of trade it is best to screen the cake, and you can do that with very little expense by placing a screen between the elevator and sacking-spout, sloping so that the cracked cake will fall over it and all the fine particles and meal will fall through. In a day's run you will get from two to three tons of screenings. All this is a saving to the consumer. The screenings can then be thrown back, put through the cake-mill and made into meal.

Do not let your cake-room fill up with bulk cake: it takes up too much room and does not present a good appearance. Make it into meal or cracked cake as your trade may demand; then your product is always ready for the market, and if you have it sacked you always know how much you have on hand, and you will not have several days' grinding to do after you shut down, as is often the case. See that the breaker does its work properly. I heard a stockman who had bought a lot of cracked cake from a mill say that the cake was so hard and in such large pieces that it gave his cattle the lump-jaw to eat it; so you see that your breaker breaks the cake into small pieces; the cake-mill will grind it easier and it will give better satisfaction to your customer. Have your cake-mill properly adjusted, well trimmed and balanced with sharp discs or plates, and

set to grind your meal to suit your trade. See that your millman keeps his scales clean and always balanced at one hundred pounds, and that the sack-sewer sews the sacks well and strong so that the ends of sacks will not burst and waste the product. Have the trucker to stack the sacks in uniform rows so they will have a neat appearance, and you can at any time check them up and get an accurate count. Keep your mill-room cleaned up; do not allow your meal to scatter over the floor and waste, and also see that your cake-mill is kept clean and well oiled.

Some mills sell their cake in bulk where it is profitable. That is a very nice way to handle cake. The superintendent is always

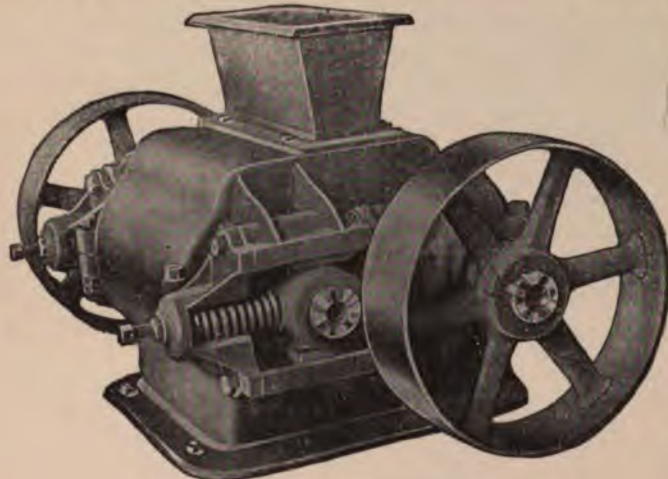


FIG. 55.—Cake-breaker.

glad when the manager informs him that he has sold a large shipment of cake, for sometimes the cake-mill will give a good deal of trouble, especially if he has a "green" crew, and then it takes considerable power to pull the mill if you have to grind very fine for export trade; so I think it advisable to ship loose bulk-cake when you can dispose of it at a fair profit and load it right from the presses to the car, pieces and all; then you are relieved of a great deal of labor and trouble.

Yield of Cake and Meal.—By reference to Table 3, it will be seen that the average yield of cake and meal per ton of seed, as ascertained by the official investigators of the XII. Census, is 713

pounds, this figure being the average of yields obtained in the different States of the cottonseed-producing territory of the United States, ranging from 800 pounds in Florida, Kansas, Missouri, and Illinois, which with the exception of Florida raise no cotton and treat only seed imported from other States, to 670 pounds in North Carolina. The average yield of 670 pounds of cake and meal per ton of seed amounts to 35.7 per cent.

Classification.—Rules for the government of transactions in cottonseed products require a ton of cottonseed-meal to be 2000 pounds unless otherwise stated. A sack of cottonseed-meal is 100 pounds gross weight.

Cottonseed-meal is graded and classed as follows:

Choice.—Must be the product from choice cottonseed-cake when finely ground; must be perfectly sound, sweet, and light-yellow color

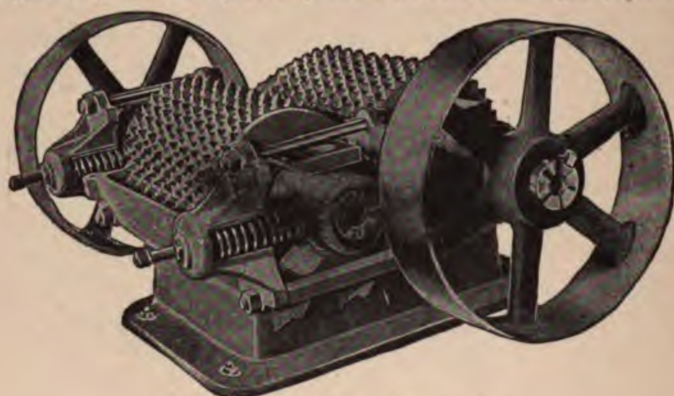


FIG. 56.—Cake-breaker—Interior View.

(canary), free from excess of lint and hulls. Analysis must show at least 8 per cent. ammonia.

Prime.—Must be made from prime cake, finely ground, of sweet odor, reasonably bright in color, yellow, not brown or reddish, and free from excess of lint or hulls, and by analysis must contain at least 8 per cent. of ammonia.

Off.—Any cottonseed-meal which is distinctly deficient in any of the requirements of prime quality, either in color, odor, texture, or analysis, or all.

When off meal is sold by sample, delivery shall equal sample in every respect except in ammonia test, and shall not be rejected

if the meal delivered tests not more than one-half of 1 per cent. less ammonia than the ammonia content of the sample, but shall be reduced by a corresponding per cent. of the contract price; otherwise it can be rejected outright.

Cottonseed-meal shall be packed in good, sound cental or laplata bags, either new or second-hand (except where otherwise stipulated for packages designed for export in kilo or other bags), 100 pounds gross weight; which must be well sewed and in good shipping order and bear a shipping-mark or a brand.

Composition.—Cottonseed-meal, as has been already explained, is the ground residue or cake left after the extraction of the oil by pressure. It is bright yellow in color when fresh, with a sweet, nutty flavor, but becomes discolored and deteriorates with age. The black specks seen in some samples show either an accidental impurity or an intentional adulteration with hulls. Its composition depends upon the composition of the seed and on the completeness with which the hulls and kernels are separated and the oil expressed. Improvements in oil machinery have constantly reduced the percentage of oil left in the cake.

The following table gives a summary of the results of over 400 analyses of cottonseed-meal with reference to food constituents, and probably shows very accurately the average composition of decorticated cottonseed-meal as found in the American market:

TABLE 11.—FOOD CONSTITUENTS OF COTTONSEED-OIL MEAL.

	Fresh, or Air-dry, Material.					
	Water.	Ash.	Protein.*	Fibre.†	Nitrogen-free Extract.‡	Fat.§
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Minimum..................	5.29	1.72	23.27	1.88	9.13	2.18
Maximum..................	18.52	10.62	52.88	15.15	38.68	20.66
Average..................	**8.52**	**7.02**	**43.26**	**5.44**	**22.31**	**13.45**

* Protein is a term used to include nominally the total nitrogenous substance, which consists of a great variety of chemical compounds which are conveniently divided into two classes, proteids and non-proteids. Actually the term is used to designate the product of the total nitrogen by an empirical factor, 6.25. As the proteids contain about 16 per cent. of nitrogen this factor is generally accepted for bodies of this class.

† Fibre is a term applied to substances allied to carbohydrates, but insoluble in dilute acids and alkalies. They constitute the framework of plants and, as a rule, the most indigestible constituent of feeding-stuffs.

‡ Nitrogen-free extract includes all carbohydrates, as starch, sugar, gums, etc., which constitute the most important part of all feeding-stuffs. In analysis it is determined by difference.

§ The term "fat" is applied to substances of mixed character forming the ether extract, and may include, besides real fats, waxes, coloring-matter, lecithins (nitrogenous fats), etc.

Its composition with reference to fertilizing constituents is shown by the following summary of results of 204 analyses:

TABLE 12.—FERTILIZING MATERIALS IN COTTONSEED-OIL MEAL.

	Water.	Ash.	Nitrogen.	Phosphoric Acid.	Potash.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Minimum.............	4.34	3.35	3.23	1.26	0.87
Maximum.............	12.57	9.90	8.08	4.62	3.32
Average...............	**7.81**	**6.95**	**6.79**	**2.88**	**1.77**

Quality and Grading of Cottonseed-meal.—In the sale of a product whose commercial value is determined by chemical analysis it is naturally to be expected that more or less frequent contentions arise between the buyer and the seller on this subject. These differences arise chiefly from the fact that different standards of quality are recognized by the producer, the broker or middleman, and the buyer. For a discussion of this branch of the subject of cottonseed-meal we can do no better than direct our attention to recent communications on this subject by Edwin L. Johnson to the *Oil, Paint, and Drug Reporter:*

"Even with sound seed there is a great variation in character of cake and meal, which is exceedingly embarrassing to buyers and causes great losses in the feeding of cattle. In view of the numerous grades of cotton and cotton-oil and the great help these grades are to the buyers in selecting what they want, it is clear that only two grades, prime and off, of cottonseed-meal are not enough for either present trade or manufacturing conditions, and that the time has come when we should no longer turn out cottonseed-meal just as it happened to run through the mill, but should vary our methods of manufacture and manipulation so as to make the meal conform to the object for which it is to be used. For instance, what is needed for the mixers of feeding-stuffs should be of high protein content; what is needed for fertilizer-makers should be of high ammonia content; and what is needed for the feeders of straight meal should be of lower protein and fat content so that it may be fed more safely with less waste and in greater quantities than at present. The market for cottonseed-meal is capable of a very great development if

the meal itself is made more uniform and with reference to the uses to which it is to be put.

"The controversy between buyers and sellers is as old as time itself. This controversy has resulted in a peculiar situation in the cottonseed industry. The standards and rules upon which the American oil-mills sell are not those upon which the foreign buyers buy. There are four separate and distinct grades of meal made from sound decorticated cottonseed sold on the market. These are: first, meal containing 7½ per cent. ammonia, recognized by the laws of the Southeastern States and at the last convention of the Interstate Crushers' Association; second, meal containing 8 per cent. ammonia, recognized by the Interstate Crushers' Association; third, meal containing 52 per cent. combined fat and protein, used by the English buyers; fourth, meal containing 58–60 per cent. combined fat and protein, used by the Continental buyers. The foreign buyers hardly recognize the first two, and the Interstate Crushers' Association does not recognize at all the last two. The middleman has to buy on one set of standards and rules and sell for export on another. Hence great confusion and the refusal of many mills and buyers either to sell or buy except upon sample or analysis. This is not a satisfactory state of affairs. It results on the one hand that the foreign buyers want the meal to contain all the ammonia or protein and fat possible, with restrictions on the amount of hulls, and on the other that the oil-mills want to make all the oil and cake they legitimately can from a ton of cottonseed. The oil-mills contend that any increase in amount of hulls lowers the ammonia content, and as they have provided an ammonia restriction on the meal, they have provided all the check that is needed on the amount of hulls in the meal, two different requirements to accomplish practically the same thing being unnecessary. They are further opposed to lumping the fat and protein contents together in a standard, on the ground that the very object of the oil-mill's existence is to get the oil out of the seed, and the more they get out the larger their profits. And so the contest goes on.

"Now is any compromise possible? After looking over the situ-

ation carefully I think there is. Compromise means concession on both sides.

"The foreign buyers would certainly get in much closer touch with the oil-mills if they would accept the ammonia basis without fat requirement for all except the very highest grade of meal, and might reasonably ask that an additional grade of meal be recognized by the Interstate Crushers' Association to take the place of their 52 per cent. combined fat and protein standard. Eight and a half per cent. ammonia meal would give them this, for it is equivalent to 43.77 protein, and the average fat of cottonseed-meal as it is made is higher than the 8.27 per cent. fat necessary to bring this to a total of 52 per cent. combined fat and protein. I suggest therefore doing away with the 52 per cent. combined fat and protein standard and substituting in its place a grade requirement of 8½ per cent. of ammonia. If the foreign buyers concede this much, I see no reason why the oil-mills should not recognize as the highest grade 60 per cent. combined fat and protein, for it is a well-known fact that no oil-mill can make this highly concentrated meal without leaving a great deal of oil in the meal in process of manufacture, and this being the case, they might as well include the fat in this high grade and get pay for it as well as for the protein. A very little of good will and concession on both sides would put our cottonseed-meal trade on a much better and more satisfactory basis and give us a single set of grades and rules instead of the present unsatisfactory and confusing double set.

"Now, it is a well-known fact that the average oil-mill man wants to be troubled as little as possible with analyses of meal. Hence it would be well to have names for these grades. We might call the 7½ per cent. meal 'Inferior'; the 8 per cent. 'Prime'; the 8½ per cent. 'Choice,' and the 60 per cent. combined fat and protein 'Extra.' But as the oil-mills would not want their meal discountenanced by such a name as 'Inferior,' and as 7½ per cent. ammonia meal is prime, both by law and Association Rules in the Southeast, it would be better to take a new name for the 8 per cent. ammonia meal and call it 'Superior,' giving the word 'Prime,' which is only a name after all, to the 7½ per cent. grade, thus avoiding confusion and putting all the States on an equality. The grades and names would then read:

"Prime cottonseed-meal, 7½ per cent. ammonia (fat not included).
"Superior cottonseed-meal, 8 per cent. ammonia (fat not included).
"Choice cottonseed-meal, 8½ per cent. ammonia (fat not included).
"Extra cottonseed-meal, 60 per cent. combined fat and protein.

"An average ton of seed I calculate would turn out according to the way in which it was worked 925 lbs., 850 lbs., 775 lbs., 700 lbs. of meal in making these grades. Hence the prices would vary and would soon be generally known and regularly quoted. As a result the oil-manufacturer who cared to follow up his cottonseed and his meal closely from week to week by analysis could select that one of these grades to make which best suited his seed, his mill, and his markets. The manufacturer who did not wish to do this need only as soon as he was well started on a new season send an average sample of his meal to some commercial body to find out its classification or grade and then sell by the grade name without troubling about analyses.

"In conclusion I would again call the attention of our foreign friends to the fact that cottonseed manufacture in the United States is a very complicated matter, as the differences in the raw product, seed, are very great from season, climate, soil, and varieties in the cotton plant. They ought not therefore to be too hasty in attributing bad faith or practice to the American manufacturer.

"On the other hand, our mills should remember that the uses of cottonseed-meal are many, and in giving the buyer a larger choice of grades they are enlarging their markets and promoting the consumption of one of their chief products."

Uses.—As will be seen by the preceding tables, cottonseed-meal is poor in carbohydrates (starch, sugar, etc.), but is rich in fat and protein (nitrogenous matter). In fact it is so rich in the latter constituent that it can be utilized to advantage as a food for animals only when mixed with some coarse fodder rich in carbohydrates, thus furnishing a more evenly balanced ration.

In comparative valuations of feeding-stuffs it has been found that cottonseed-meal exceeds corn-meal by 62 per cent., wheat by 67 per cent., and raw cottonseed by 26 per cent. As regards digestibility, cottonseed-meal compares very favorably with other concentrated feeding-stuffs, as the following statement of the amounts

of digestible food ingredients in 100 pounds of meal will show: Protein, 37.01 pounds; carbohydrates, 16.52 pounds; and fat, 12.58 pounds.

Cottonseed-meal is extensively used as a fertilizer, and for this purpose the price is determined on the same basis as that used in calculating the value of other commercial fertilizers. It frequently happens, even in Northern States, that cottonseed-meal can be bought for less than its fertilizing value, calculated on the above basis.

Although cottonseed-meal contains considerable percentages of phosphoric acid and potash, a large proportion of which has been shown to be readily available to plants, it is chiefly used as a source of nitrogen in fertilizers. Cottonseed-meal has given excellent results, especially in the Southern States, as a fertilizer for sugar-cane, cotton, and corn. It has also been successfully substituted for barnyard manure in the culture of tobacco.

While cottonseed-meal, as the above facts show, has high value when applied directly as a fertilizer, a more rational practice is to feed the meal to animals and apply the resulting manure to the soil. From 80 to 90 per cent. of the fertilizing materials of the meal will thus be recovered in the manure, and additional benefit will be secured in the production of meat, milk, etc.

Determination of Oil in Cottonseed-oil Cake.—Frequent determinations of the amount of oil left in the cake should be made, not only for ascertaining the efficiency of operation of the press, but for ascertaining as well the absolute percentage of oil in the cake, as an ingredient of a marketable commodity. The same determination should be applied to the seed, which vary greatly in oil content according to the season, degree of maturity, and geographical origin. The principle of the determination is that of simple extraction of the oil with petroleum ether, the evaporation of the ether extract, and the weighing of the residue. For this purpose a variety of fat-extraction apparatus are in use. The simple method of fat extraction described as used for determining free fat in soap-stock is likewise applicable to powdered oil-cake. The apparatus is inexpensive, and the results, while not absolutely accurate, are sufficiently so for technical purposes. Instructions for using the

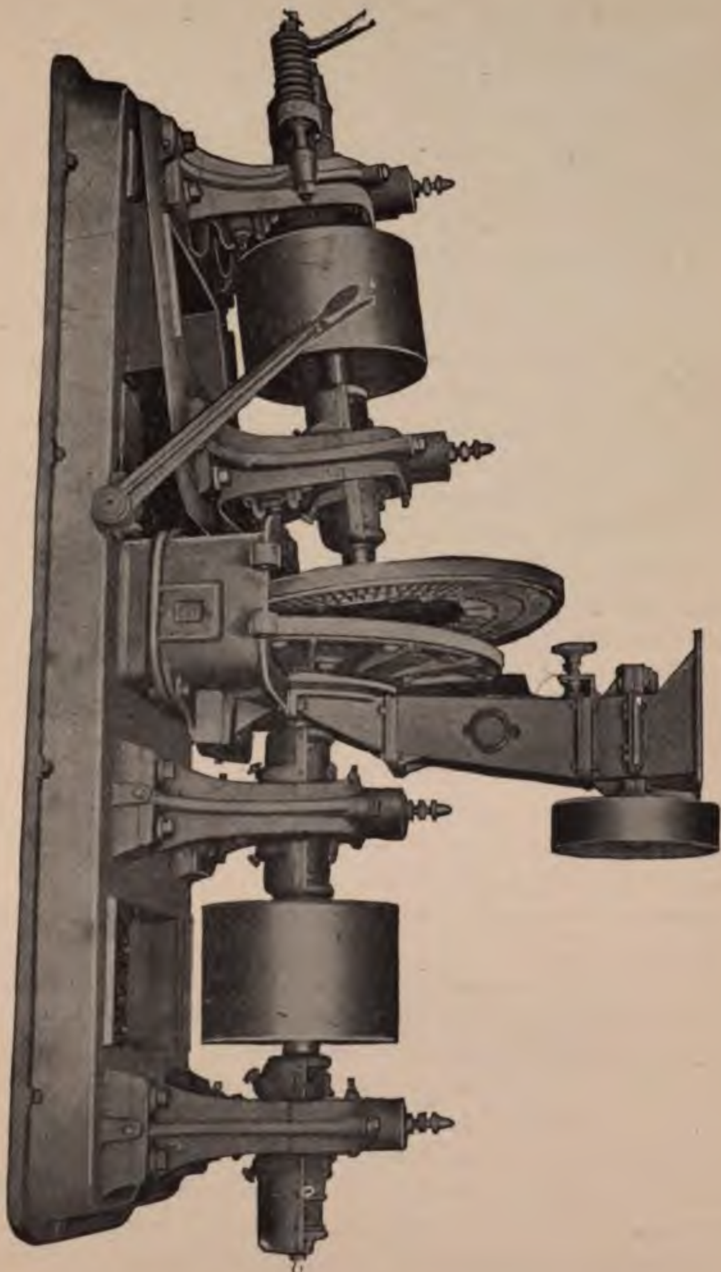


FIG. 57.—Cake Grinding-mills.

various forms of extraction apparatus are available in advanced treatises on chemical analysis.

Cottonseed-hulls.—The hulls, as detached from the meats by the huller and separated from them by the hull and meat separator, constitute almost one-half of the weight of the seed. By reference to Table 3, this proportion for the entire cottonseed-producing territory is seen to average 943 pounds. The hulls are hard and dry and retain varying amounts of fuzzy lint that has escaped removal in the delinter. They are so bulky as to make storage difficult and are liable to heat when stored in bulk. As fast as they accumulate it is customary to put them up into bags or bales containing 100 pounds each. Analyses of hulls show them to be chiefly crude fibre and nitrogen-free extract matter, these two constituents, with water, constituting more than 90 per cent. of the hulls. Hulls, even from the same mill, however, vary widely in composition, owing to imperfect removal of the lint or the adherence of more or less of the kernel. The following table shows the minimum, maximum, and average composition of the hulls, compiled from 22 analyses:

TABLE 13.—FOOD CONSTITUENTS OF COTTONSEED-HULLS.

	Fresh, or Air-dry, Material.					
	Water.	Ash.	Protein.	Fibre.	Nitrogen-free Extract.	Fat.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Minimum	7.25	1.65	2.78	35.75	12.41	0.75
Maximum	16.73	4.43	5.37	66.95	41.24	5.41
Average	**11.36**	**2.73**	**4.18**	**45.32**	**34.19**	**2.22**

Before the general recognition of the value of hulls alone, or as a diluent for richer food, as cottonseed-meal, for cattle, a large proportion of the amount obtained was used for fuel at the mills.

The utilization of the hulls in the manufacture of paper-stock is an industry of stupendous possibilities which has not as yet emerged beyond the experimental stage. The suitability of the hull with the adhering fibre as raw material for certain grades of paper, notably blotting, board, and for mixing with other stock for

writing-paper has been demonstrated, but obstacles arising chiefly from inexperience in its treatment, loss in bleaching, and the use of machinery and appliances different from that required for wood- and rag-pulp, delay a general recognition of what at no remote date will be regarded as a valuable paper-stock.

Bockmeyer describes a process of treatment whereby cottonseed-hulls, cotton-waste, and other vegetable fibre may be decolorized and otherwise rendered fit for various uses and applications in the arts.

The strengths of the solutions to which the material is subjected and which are given hereinafter in the detailed description of the process are particularly adapted for the treatment of cottonseed-hulls, and the various steps involved in the process are therefore to be understood, with respect to composition of the solutions used, as applying to the employment of cottonseed-hulls for a raw material.

In carrying the present process into practical effect the hulls after having been ground by suitable means (and if other vegetable material is used this likewise being reduced to a comminuted condition) are subjected in a proper receptacle to the action of an alkali. This alkali may be in solution, for the making of which commercial sodium or potassium hydrate may be used. This solution is preferably a one- or two-per-cent. solution approximately, and it is preferred to pass live steam into the mixture from one or two hours, as may be found necessary. The alkali serves not only to cleanse the waste, but to saponify and remove the oily matters that may be present, and tends to break down the intricate structure of the seed-shell particles disseminated as a result of the grinding operation throughout the mass. In this loosened condition such particles more readily and effectively undergo the subsequent decolorizing or bleaching process. If it is desired before passing to the next step to remove the oily matters, dirt, etc., taken up or rendered soluble by the alkali, the solution is then drawn off and the mass washed with water. The washed hulls, etc., are now again mixed with a one-per-cent. alkaline solution which may, as before, be made from sodium or potassium hydrate. The presence of this free alkali tends to prevent the contraction of the shell structure and the collapse of the fibre-tube of the cotton. Chlorin gas is thereupon passed through

the mixture until the hulls, etc., are completely decolorized and bleached, it being desirable that the mass be kept in agitation while the gas is passing in, in order that all parts of the mixture may be reacted upon thereby. The chlorin will act on the coloring-matter of both the fibre and the seed-shell particles, as well as upon the alkali, it being therefore present during the decolorizing process in a nascent state. With the alkali the chlorin forms a soluble compound, which with other soluble matter may, if desired, be removed before the subsequent "souring" operation by removing the liquid from the bleached product and thoroughly washing the latter with water. The next step in the treatment involves the subjection of the chlorin-impregnated mass to a reagent or reagents capable of forming, with the excess chlorin present, an inert compound without effecting the reaction or resulting thereafter in a permanent return of objectionable discoloration. Such a reagent is oxalic acid, and if this be used the bleached hulls are next thoroughly mixed with a solution of the acid and left for a period of thirty minutes to an hour, after which the mass is thoroughly washed with water, yielding the finished product. This is drained and may afterward be dried or not, as desired.

Instead of the oxalic-acid treatment the hulls after bleaching may be first mixed with a one-quarter-of-one-per-cent solution of ammonia and then with a one-quarter-of-one-per-cent solution of carbonate of soda.

The strengths of solutions given have been found to yield good results in practice, although, of course, Bockmeyer does not limit himself to the exact percentages specified. Moreover, while solutions of the specified strengths have been used for the treatment of cottonseed-hulls with the result of obtaining a clear white highly absorbent fibre free from spots and discoloration, in the event of employing vegetable materials or fibre of other characters, experience has demonstrated that the percentages specified should be somewhat modified to secure the best and most commercially satisfactory product.

A more extended preparation of the hulls for feeding purposes consists in grinding and bolting, the finished product resembling linseed-meal in appearance. This product is mixed in varying

proportions with cottonseed-meal and sold under the name of cottonseed-meal bran as a combination food, analysis showing that in its essential nutritive ingredients it is superior to wheat-bran.

Cottonseed-hull Ashes.—Cottonseed-hull ashes have been on the market since 1880 and have come into great demand as a cheap potash supply, especially among tobacco-growers. The quality of these ashes varies greatly on account of impurities introduced, principally by the use of other fuel, with the hulls. The following table gives a summary of 185 analyses of this material:

TABLE 14.—FERTILIZING CONSTITUENTS IN COTTONSEED-HULL ASHES.

	Water.	Phosphoric Acid.	Potash.	Lime.	Magnesia.	Carbonic Acid.
	Per Cent.	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Minimum	0.25	2.37	7.02	0.86	2.85	9.56
Maximum	22.30	15.37	44.72	19.35	17.15	11.59
Average	**9.00**	**9.08**	**23.40**	**8.85**	**9.97**	**10.57**

The potash exists largely as carbonate, which is readily available to plants, but there is also a considerable percentage of silicate of potash which is difficulty available. The value of cottonseed-hull ashes depends almost exclusively upon the amounts of potash and phosphoric acid they contain.

CHAPTER IX.

MANUFACTURE OF OLEOMARGARINE AND LARD-COMPOUND.

Utilization of Cottonseed-oil for Edible Purposes. Manufacture of Oleo-stearin and Oleo-oil. Manufacture of Neutral Lard. Manufacture of Oleomargarine: Historical; Apparatus; Ingredients; Use of Cottonseed-oil; Procedure of Manufacture. Manufacture of Lard-compound: Ingredients; Manufacture of Lard-stearin. Mixing. Some Fertilizer History.

Utilization of Cottonseed-oil for Edible Purposes.—The perfect edibility of refined cottonseed-oil permits its use for every purpose for which animal fats are commonly used. Its most important use for edible purposes is in the manufacture of a substitute for the fat of swine, or lard. This substitute has come to be known as lard-compound. It consists of summer white cottonseed-oil and oleo-stearin mixed in various proportions, and sometimes with a small percentage of genuine lard. The use of next importance is in the manufacture of a substitute for butter. This product is commonly called oleomargarine. It is made in various grades according to the proportions of the different ingredients used. The characteristic ingredients are oleo-oil and neutral lard, with varying amounts of summer yellow cottonseed-oil according to the quality of the finished product, together with milk, salt, and coloring-matter. In grades of superior quality some butter may be used.

Important direct uses of refined cottonseed-oil are: as a table or salad oil, for which winter yellow oil is commonly used; for packing sardines, for which summer yellow oil is used; and as a complete or partial substitute for many purposes for which olive-oil is used.

Manufacture of Oleo-stearin and Oleo-oil.—Oleo-stearin is the base of lard-compound; oleo-oil with neutral lard is the base of oleomargarine. They are obtained from choice beef fat by a process of

heating the finely divided fat in open kettles, removing and washing the liquid fat to separate the tissue; then crystallizing the fat and subjecting it to pressure whereby the oleo-oil separates as a liquid, leaving the stearin as a solid fat.

After the animal is slaughtered the fat is removed and placed in a vat of warm water, where it is thoroughly washed to remove blood and adhering impurities. It is then chilled and hardened with a bath of ice-water, after which it is finely comminuted by cutting-machines and melted in steam-jacketed caldrons at a temperature of about 160° Fahr. Slowly revolving agitators keep the fat moving until the melting process is complete, when the whole is allowed to settle. Fig. 58 represents a car of comminuted fat from the cutting-machine being dumped into the melting-kettle. The settling process is accelerated by the addition of salt, which is scattered over the entire surface of the liquid and settles the fibre or "scrap" to the bottom. After the first settling the clear oil is carefully siphoned to a second series of jacketed caldrons, usually on the floor below, where more salt is added, and the temperature controlled until a second settling is completed. This demembranized fat is now siphoned into mounted vats and allowed to stand from three to five days in a temperature favorable to the crystallization of the stearin, a part of which forms a crust over the top and the remainder settles to the bottom, leaving the clear oil between. It is a common phenomenon in the crystallization of various substances whose specific gravity is not greatly in excess of the mother-liquor that, cooling first at the top, a portion of the substance which is being crystallized out forms a crust over the surface and the remaining portion is precipitated. When the vats have stood the required time the crust is broken into fine particles and the whole is given a thorough mechanical mixing, which leaves it of a mushy consistency. It is then wheeled to a revolving table surrounded by skilled workmen, who wrap the mixture into small packages with canvas cloths, each containing about three pounds, which are built into the presses. The oleo-oil is then separated by great pressure, slowly and gradually applied, and flows from the presses into a large receiving-tank on the floor below, from which it is piped to the oleomargarine department or is drawn into new oak tierces

and allowed to harden in preparation for shipment to independent manufacturers or for export. Fig. 59 shows two presses, one filled and the other in process of being filled.

FIG. 58.—Melting Beef-fat for Oleo-oil and Oleo-stearin.

All manufacturers of oleo-oil follow substantially the method above described, but the system of grading and the character of the fat selected differ greatly. The number of grades manufactured is from three to five, and when the market is active and prices are high, about all the fat taken in slaughtering, both from cattle and sheep, is worked into one grade or another. The oil made

from sheep fat cannot be neutralized. It retains the characteristic odor and flavor of the animal to such degree as to be unfit for the oleomargarine demanded in American markets. It is exported to Europe, where there is demand for cheaper oils. With the beef fats the character of the animal from which they are taken is the most potent factor in the selection. Some manufacturers work

Fig. 59.—Separating Oleo-oil from Stearin of the Fat by Pressure.

into their highest grade of oleo-oil practically all the fat taken from a good steer and make one or two lower grades from the fat of cows and "canners." Other manufacturers make their highest grade from the caul and other selected fats of the best beeves, using certain intestinal and other lower forms, together with that taken from poorer animals, in making from one to three lower grades. The quantity of oleo-oil obtained by the process described is, by weight, about 50 per cent. of the fat treated. About 28 per cent. is stearin and the remainder is shrinkage. The quantity obtained from each beef is difficult of exact determination because it varies so greatly with size and condition of the animal when slaughtered.

Manufacture of Neutral Lard.—Neutral lard is composed of the fat derived from the leaf of the slaughtered animal, taken in a perfectly fresh state. Two grades are made—one from the leaf, the other from the back fat of the hog. Its manufacture is almost exclusively confined to large packing-houses, but there are independent manufacturers of oleomargarine located near the packing centres who prefer to buy the fat as it is taken from the animal and work it into neutral by their own process. In the packing plants the leaf fat is taken from the animal immediately after killing, hung on mounted racks, and wheeled into refrigerators to remove as quickly as possible all animal heat. It is next chopped finely or reduced to pulp by machinery and melted in jacketed kettles exactly similar to those used for oleo-oil. When the melting process is complete it is allowed to settle, the precipitation of the fibre being accelerated by the addition of salt as in the case of oleo-oil. After the settling process the clear oil is siphoned to a receiving-tank, and what is not used in oleomargarine is tierced for shipment. A good quality of leaf fat will produce by careful handling about 90 per cent. of its weight in neutral, and each animal will yield an average of eight or nine pounds. Comparatively little neutral is made from back fat. The amount used, however, depends much on the relative demand for neutral and ordinary lard products, as it is sometimes more advantageous to work fats into one form than another. The oil made from back fat retains more of the flavor peculiar to lard and, like the lower grades of oleo-oil, is less free from stearin or other undesirable constituents. Some packing-houses mix a small per cent. of back fat with the "leaf" in making their highest grade of neutral, and oleomargarine manufacturers sometimes use both grades of the finished oil in combination. The difference in price between the two is usually slight, and neutral made exclusively from "leaf" is generally sought. Independent manufacturers of oleomargarine, who make their own neutral lard, give the fat a more extended treatment than that described as the process of the packers. In addition to the separation of the fibre by the process of settling the clear oil is drawn into a large vat of salt water at a low temperature, where it is again chilled and hardened, and is allowed to remain for several hours. It is then placed on shelves to drain

and is again melted when ready for churning. This treatment carries the neutralizing process to a higher degree of perfection and improves the texture of the oil.

Manufacture of Oleomargarine. — *Historical.* — Oleomargarine was first manufactured in France. In 1869 the French war office, at the instance of Napoleon III., who was desirous of discovering a substitute for butter that would keep longer and also increase the dietary of the poor, offered a prize for the best substitute for butter, which was won by M. Mége-Mouries, a Parisian chemist. After a series of observations and experiments, Mége-Mouries was persuaded that the butter fat contained in milk was absorbed from the animal tissues of the cow, and his attention was then directed to the discovery of a process that would separate from beef fat the oil similar to that in milk. The method finally devised by him for the manufacture of oleo-oil (called then oleomargarine or oleomargarine-oil) was to heat finely minced beef fat with water, carbonate of potash, and small fragments of fresh stomachs of sheep, to a temperature of about 115° Fahr. The influence of the heat, together with the pepsin contained in the sheep's stomach, separated the fat from the cellular tissue. This fatty matter was then removed and when cool was subjected to hydraulic pressure sufficient to separate the stearin. The oleo-oil was then churned with milk and water in the proportion of ten pounds of oleo-oil to four pounds of milk and three pints of water. The resulting compound was washed and declared ready for use.

Apparatus.—In the manufacture of oleomargarine so much depends on the handling of the constituent oils and the manipulation of the temperatures by which they are surrounded throughout the different stages of the process, that equipment for live steam, ice-water, and refrigeration is the indispensable requisite of every establishment. Aside from this, the equipment consists principally of power machinery, viz., melting-tanks, mixing-tanks, milk receptacles, churns, and machine butter-workers. The butter-workers are such as are used in creameries throughout the United States. In some factories the churns are similar to those used in creameries, but oftener they are large, upright, jacketed caldrons in which the milk and color, usually annatto or saffron, are mixed with the melted

oils by a violent churning or stirring produced by revolving or rotating agitators inside. By the introduction of steam into the jacket the operator controls the temperature and the degree of liquefaction until the churning process is complete. By the same means any considerable quantity of oleomargarine is prevented from congealing on the side of the churn while the contents are being drawn off.

Ingredients.—The number and character of the ingredients of oleomargarine make them susceptible of almost an infinite number of combinations, and each manufacturer has his own working formula. So much depends on the handling of the oils and the regulation of temperatures surrounding them at each successive step that different manufacturers using the same quality of ingredients in similar combination will secure vastly different results. A formula for each of three distinct grades of oleomargarine, of general manufacture, is given below to show the use of different ingredients and their variation in quantity.

FORMULA 1.—CHEAP GRADE.

	Pounds.
Oleo-oil	495
Neutral lard	265
Cottonseed-oil	315
Milk	255
Salt	120
Color	1¼
Total	1,451¼

will produce from 1265 to 1300 pounds of oleomargarine.

FORMULA 2.—MEDIUM HIGH GRADE.

	Pounds.
Oleo-oil	315
Neutral lard	500
Cream	280
Milk	280
Salt	120
Color	1½
Total	1,496½

will produce from 1050 to 1080 pounds of oleomargarine.

FORMULA 3.—HIGH GRADE.

	Pounds.
Oleo-oil	100
Neutral lard	130
Butter	95
Salt	32
Color	$\frac{1}{2}$
Total	$357\frac{1}{2}$

will produce about 352 pounds of oleomargarine.

Use of Cottonseed-oil.—Summer yellow cottonseed-oil is used as a partial substitute for oleo-oil ~~or~~ and neutral lard. It never fully replaces them, but is added to some combination of those two ingredients to cheapen the product. It is a liquid within the range of temperature to which butter is exposed, and its use is, therefore, limited to such a proportion in any formula as will not soften the product beyond the usual consistency of butter.

Aside from the consistency of the product, a too-pronounced flavor of the oil is the greatest restriction to its use. To make a high-grade oleomargarine it is absolutely essential that all its constituent oils respond fully to the neutralizing treatment by which their characteristic odors and flavors are removed, so that they will take on the flavor of butter from the aromatic principles of the milk or cream with which they are churned.

Procedure of Manufacture.—In plants where both oleo-oil and neutral lard are purchased for use, melting-tanks are provided for each, in which they are melted separately after being taken from the tierces in which they are shipped. They are then piped or pumped to a mixing-tank mounted on weighing-scales, where the exact proportions demanded by the working formula are ascertained. If cottonseed-oil is required by the formula, a separate tank for it is usually provided. If butter is to be used instead of milk or cream, a separate melting-tank is also provided for that. After the oils are melted and weighed into the mixing-tank together, the mixture is piped or pumped into the churn, where it receives the milk and coloring-matter. The whole mass is then churned together. In the packing-houses liquid oleo-oil and neutral lard are piped from the oil-room direct to the weighing-tank. After

churning, the liquid oleomargarine is allowed to flow into a vat of ice-water, which chills and hardens it before crystallization can take place. It is next shovelled into mounted cars and wheeled to the "tempering-room," where it stands for several hours, until sufficiently softened for the machine butter-workers. After the salt has been worked through it, it is put up in the different forms demanded by the market, and is stored in refrigerators to await shipment. Fig. 60 represents an actual scene in the churning-

FIG. 60.—Churning Oleomargarine.

room of a large factory. At the left of the picture is seen a quantity of oleomargarine which has just been taken from the chilling-vat after churning, and is ready for the "tempering-room." At the right the contents of a churn are being drawn off into the chilling-vat. The pipe descending from the ceiling brings a stream of ice-water from a reservoir above into immediate contact with the stream of liquid oleomargarine for the purpose of chilling it as quickly as possible. Fig. 61 represents the working and salting process, and Fig. 62 a scene in the preparation of the finished product for market.

While there is a substantial uniformity in the process of manufacture, there is great diversity in the grades and combinations of material used and consequently in the character of the finished article. The cheapest grades of oleomargarine found on the market are made from the lowest grades of oleo-oil and neutral lard, to which is added the limit of cottonseed-oil, and the whole is churned with skimmed milk or buttermilk, salted with common salt, and colored with the cheaper grades of coloring-matter. These low-

FIG. 61.—Working and Salting Process after Churning and Tempering.

grade oils may be manufactured from "scrap" fat and made firm by the addition of more stearin or other similar substances so that a greater proportion of cottonseed-oil can be added to the combination. Sometimes glycerin is added to give the product a glossy appearance and sugar or glucose to sweeten or give texture. The highest grades are made from pure oleo-oil and neutral lard of best quality, churned with whole milk, cream, or creamery butter, salted with Ashland salt, and colored with annatto or other

coloring-matter. The number of grades manufactured varies from two to six.

Manufacture of Lard-compound — Ingredients. — The ingredients of lard-compound are summer white cottonseed-oil and oleo-stearin. To this admixture may be added varying amounts of genuine lard; the oleo-stearin may also be replaced in varying amounts by lard-stearin.

Lard-stearin used in lard-compound is made, as a rule, from

FIG. 62.—Packing Oleomargarine for Market.

prime steam lard, which is defined by the Chicago Board of Trade as solely the product of the trimmings and other fat parts of hogs, rendered in tanks by the direct application of steam and without subsequent change in grain or character by the use of agitators or other machinery. Prime steam lard may be greatly improved in quality by washing with water containing sodium chloride and sodium carbonate and settling and then bleaching the lard thus purified with fullers' earth. The proportions of the ingredients

of lard-compound are various according to the quality of the product desired, the competing prices of raw materials, and the season, whether summer or winter. Of oleo-stearin or lard-stearin, or mixtures, 20 to 30 per cent., and of summer white cottonseed-oil, 70 to 80 per cent., are the proportions commonly used. The admix-

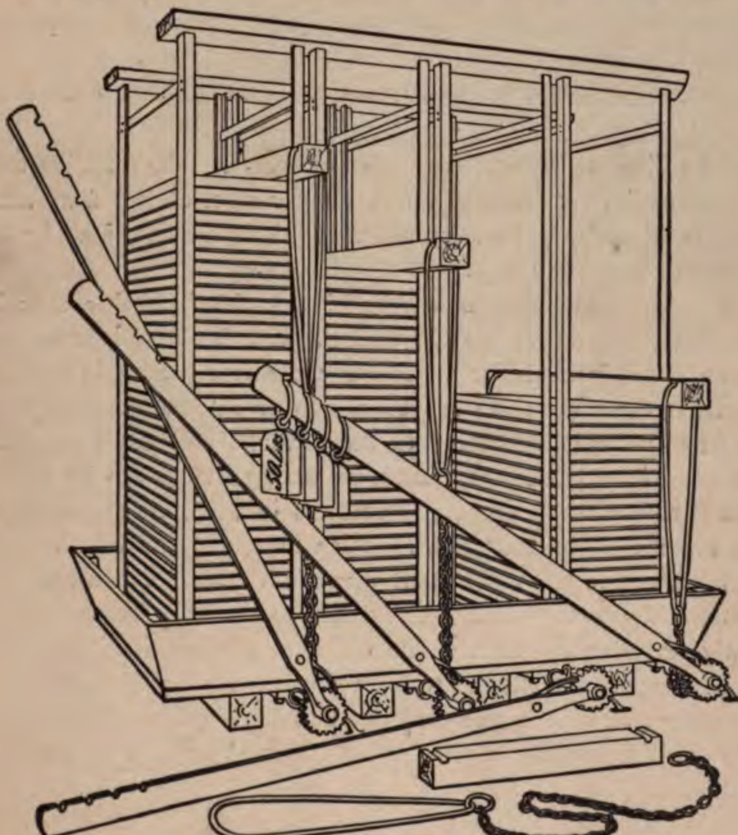


FIG. 63.—Lever Lard-press.

ture of lard of any given quality is a matter dependent on market conditions and the judgment of the manufacturer.

Manufacture of Lard-stearin.—Lard-stearin is made in the same general manner as oleo-stearin. The process of manufacture as described in Bull. 13, U. S. Dept. of Agriculture, is as follows: The prime steam lard, if properly crystallized and of the right tempera-

ture (45° to 50° Fahr. in winter, 55° to 65° in summer), is sent at once to the presses. If not properly grained it is melted and kept in a cooling-room at 50° to 60° Fahr., until the proper grain is formed. The lard is then wrapped in cakes with cloth, each cake containing ten to twenty pounds. The cakes, separated by iron plates, are then placed in a lard-press (Fig. 63). These presses are sometimes 40 to 50 feet in length, and when first filled 12 to 18 feet high. Pressure is applied very gradually at first by means of a lever working a capstan, about which a chain is wrapped, attached to an upper movable part of the press. The oil expressed, prime or extra lard-oil, is used for illuminating and lubricating purposes. The resulting cake is lard-stearin. It contains about 0.5 per cent. of free fatty acids (less than lard-oil) and crystallizes in long needles, making the texture of the cake tough.

Mixing.—The mixer is a cylindrical tank of suitable capacity containing a vertical shaft, provided with horizontal arms and driven by belt from shafting. The ingredients in the liquid state are run from the respective storage-tanks to an intermediate weighing-tank and weighed, according to the formula, and are thence run into the mixer. The temperature of mixing should not be greater than is sufficient to keep the ingredients in a liquid state and may run from 120° to 160° Fahr. When thoroughly mixed, the compound is run to the lard-cooler, where it is chilled, and thence into cans and tierces for market. The lard-cooler comprises essentially slowly revolving cylinders within which cold brine circulates. The liquid compound is allowed to flow upon the moving cylinders which are supported over a pan and dip into the liquid collected in it. By regulating the flow of the liquid compound and the temperature of the brine, the cooling process may be made very rapid and continuous.

Soaker
Filler
Tester
labeler

CHAPTER X.

MANUFACTURE OF SOAP AND SOAP-POWDER.

Utilization of Cottonseed-oil in Soap Manufacture. Factory Equipment. The Soap-kettle. Caustic-lye Tanks. The Soap-pump. The Soap-crutcher. The Soap-frame. Slabber and Cutting-table. Drying of Soap. Dry-room. Pressing Soap. Theory of Saponification. Soap-manufacturing Processes. Characteristics of Cottonseed-oil as Raw Material for Soap Manufacture. Settled Soap. Manufacture of Settled Soap. Stock Change. Rosin Change. Strengthening Change. Finishing Change. The Nigre. Crutching and Framing Soap. Manufacture of Soap from Cottonseed-oil Soap-stock. Manufacture of Soap-powder. Mixing and Framing. Grinding Soap-powder. Packing Soap-powder. Continuous Method.

The Utilization of Cottonseed-oil in Soap Manufacture.—The proportion of refined cottonseed-oil unavailable for edible purposes varies within wide limits (from 15 per cent. to 65 per cent.) owing to varying quality of the seed and to varying skill employed in their manipulation. This grade of oil is available for numerous industrial purposes, chief of which is soap manufacture. For this purpose it has to compete in price with animal fats. It is an excellent soap-stock, clean, uniform in quality, easily handled, and possesses qualities when transformed into a detergent that admirably adapt it for admixture with the firmer glycerides of animal origin. For the manufacture of certain kinds of soap for industrial or mill use, it is frequently used without admixture with other stock, but for laundry and toilet soap, best results are obtained when used with either tallow, or cocoanut-oil, or both. To make a description of the use of cottonseed-oil in the soap industry of practical value, it will be necessary to give a more or less thorough discussion of the procedure of soap-boiling itself.

Factory Equipment.—In pursuance of a strong economic tendency hastened by keen competition, recent years have witnessed

a general unification of productive efforts in all the manufacturing arts. In the cottonseed-oil industry we find this tendency expressed logically first in the effort to control the supplies of cottonseed by the crushers; next a co-operative effort among crushers to more economically produce the various products obtained by refining. Consumers of refined cottonseed-oil, notably the meat-packing and provision establishments, where consumption has been of sufficient volume to warrant the undertaking, have engaged in the crushing and refining of cottonseed-oil. Numerous firms in the soap industry likewise have become interested in cottonseed-oil manufacture. On the other hand, cottonseed-oil producers, cognizant of a growing domestic and export market for the commodities of which their product forms an essential ingredient, have undertaken the manufacture of these commodities themselves, and in many instances throughout the oil-producing territory with signal success. We have already dwelt upon the procedure and equipment required for the manufacture of oleomargarine and lard compound. At this place our attention is directed to the factory equipment essential to the utilization of cottonseed-oil in the manufacture of soap and soap-powder. Soap manufacture as an allied enterprise is one that may be readily annexed to cottonseed-oil refining, as it represents but a step further in the utilization of the product, and in many cases factory space may be already available, or at any rate provided with but comparatively small additional outlay.

The essential equipment for soap manufacture comprises kettles for boiling the soap, tanks for melting caustic soda and storing the lye where this product is bought in the solid state, a crutcher for mixing additional detergent matter with the soap, frames for receiving the mixed soap from the crutcher and in which it is allowed to remain until cold and firm, a slabber and a cutting-table for reducing the mass of soap in the frame to a size required, wooden racks upon which the cut soap is allowed to remain until sufficiently dry to press, and a soap-press, with suitable dies, which may be operated either by foot-power or steam, whereby the cut and dried soap is reduced to any desired form. Where it is not convenient to run the soap directly from the kettle to the crutcher by means of a trough, a rotary pump will be required. This device is a common implement

in the cottonseed-oil mill and may be used with equal ease for both oil and soap.

Storage tanks for waste soap-lye will be required, varying in number and capacity according to the amount of stock killed and the economy of treating the waste lye for the recovery of glycerin.

The Soap-kettle. — The soap-kettle is similar in construction to the cottonseed-oil refining-kettle and may be used for both soap-making and oil-refining. Agitation with air is unnecessary. Heating may be effected with either open or closed steam or both. With open steam alone, which is sufficient for all requirements, the pipe may be either of the coil or criss-cross type, the latter being cheaper of construction and equally efficient. The swing-joint pipe, used in the refining-kettle for the decantation of the clarified oil, also serves in the soap-kettle for running off the settled, finished soap to the crutchers. The capacity of the kettle is indefinite; a small batch as well as the full yield of the kettle can be made with equal ease. A kettle 12 feet in diameter and 16 to 18 feet deep should yield at least 60 frames of soap, a frame holding, as a rule, not less than 1200 pounds. Under ordinary circumstances the soap-kettle should be jacketed to prevent loss of heat by radiation during boiling and too rapid cooling during settling. Wood may be used for this purpose, with an air space left between the jacket and the kettle. Asbestos covering is also coming into use. Many other considerations, especially when the kettles extend through two or more floors, require that the heat of radiation be lessened.

Caustic-lye Tanks.—The manufacture of caustic soda from soda-ash by causticization with quicklime has been already described. Where conditions warrant the manufacture of caustic soda in this manner the caustic-soda liquor is transferred by pump or by gravity directly to the soap-kettle as required. Where caustic soda is bought in the solid form, usually in sheet-iron drums weighing about 700 pounds each, its treatment involves the removal of the sheet-iron envelope, the reduction of the solid caustic to a concentrated solution, and the dilution of the concentrated solution to the strength desired. For this purpose two tanks are necessary, preferably of a rectangular cross-section and of a capacity in accordance with the amount of caustic used. In order to effect the most

convenient transfer of the caustic lye not only from the melting-tank to the storage-tank, but from the latter to the soap- or refining-kettle, the tanks should be located at a higher level than the kettle in which the caustic lye is to be used, thus permitting its transfer by gravity. The dilution of the concentrated lye discharged from the melting-tank into the storage-tank is most conveniently effected by connecting, by means of a T and a valve, the water-pipe with the pipe leading from the lye-storage tank to the soap-kettle. By suitably regulating the volume of discharge of water and caustic lye, the latter may be diluted to any desired strength.

The Soap-pump.—The common form of soap-pump is of the rotary type and is characterized by one or more projections, acting as plungers, fixed to an axle and revolving in a cylindrical case provided with suitable pipe connections for the ingress and discharge of the material moved. Rotary pumps in general have a certain field, outside of which they are not desirable, but within its limits

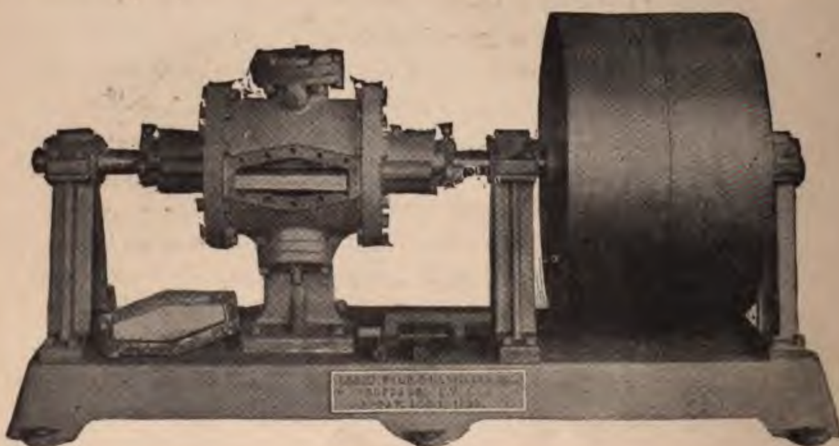


FIG. 64.—Rotary Pump.

they have most decided advantages. A rotary pump is hardly suitable as a fire-pump, as the pressure in the discharge-pipe can hardly be raised to and sustained at 60 pounds; but rotary pumps have one great advantage, that with relatively little steam or power they will lift a large amount of liquid against a limited pressure In Figs.

64 and 65 respectively is shown the exterior and interior construction of a common form of pump of this type.

The four valves, Fig. 65, the vital part of the pump, are formed in two pairs, one valve having two parallel arms provided with longitudinal ribs or tongues, and the other valve having two parallel arms

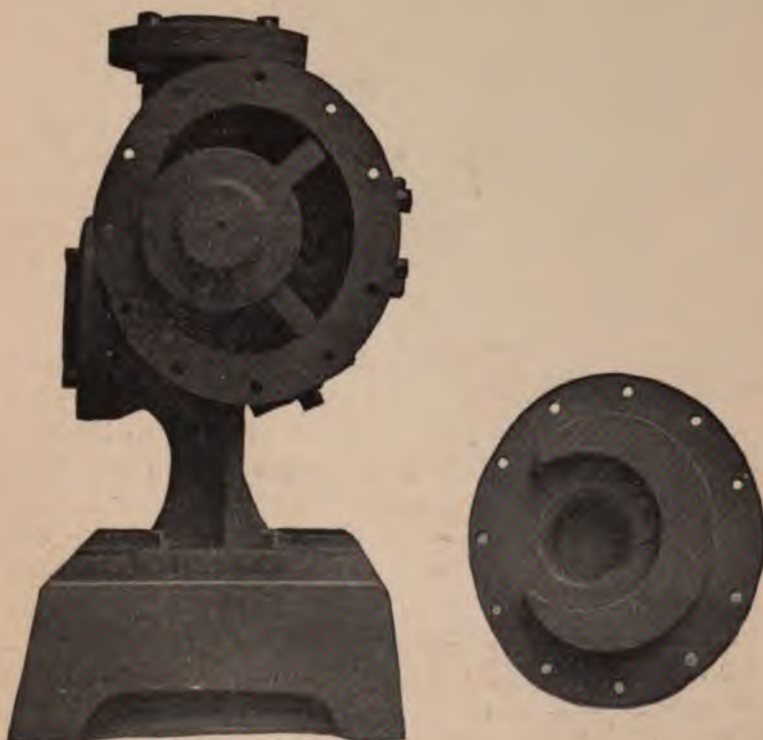


FIG. 65.—Rotary Pump—Interior Construction.

provided with longitudinal depressions or grooves, forming slideways in which the ribs or tongues upon the arms of the other valve seat and travel.

By this arrangement they are always kept in position to work, are self-adjusting, requiring no springs or cams to operate them whatever, they being positive in their action, and are like two solid valves,

which prevent lateral motion, back-lashing, and from getting wedged in the slideways of the piston.

These two pairs or four valves are interchangeable, and the wear can be easily taken up by means of putting set-screws in the arms which are of the same thickness as the valves.

The piston which carries the four valves and through which they slide back and forth during their operation is made wide at both ends and prevents it from breaking.

This extra width of piston is taken up by two half-moon pieces, which conform to the inside of the shell, and are bolted on to each one of the two heads of the shell. This prevents the valves from wearing against the heads of shell. The wear on the half-moon pieces can be easily taken up by removing them from the heads of shell and placing a strip of paper or other suitable packing between them and the heads of the shell.

The shell has a removable plate or hand-hole, Fig. 64, whereby ready access to all the working parts of the pump is possible without dismantling the pump or withdrawing the piston from the shell. All rotary pumps should not be located over ten feet above the surface of the liquid to be pumped, and should be placed preferably below the level in order that gravity may assist in the flow of the material to the pump.

The Soap-crutcher. — The mechanical soap-crutcher is an evolved form of the simple hand-crutch, which consists of a rod to one end of which is attached at right angles a short piece of wood or metal. By laboriously moving this device up and down in the mass of semi-liquid soap contained in a frame, cooling of the soap was hastened, whereby either separation of nigre was prevented or filling material was incorporated.

The modern power-driven crutcher consists essentially of a cylindrical tank, as a rule of about 1200 pounds capacity, made of sheet steel or boiler-iron, either plain or jacketed, and supporting the driving-gear of the agitator. The agitator may be arranged either horizontally or vertically according as to whether the crutcher is of the horizontal or vertical type. The agitator consist of blades or arms securely attached spirally to the horizontal or vertical shaft. In the vertical type of crutcher agitation may also be effected by

means of an Archimedean screw enclosed within an inner, vertical, concentric cylinder, whereby mixing of the soap and of the material added to it is effected by the movement of the mass up through the inner cylinder and down through the outer cylinder, or the reverse.

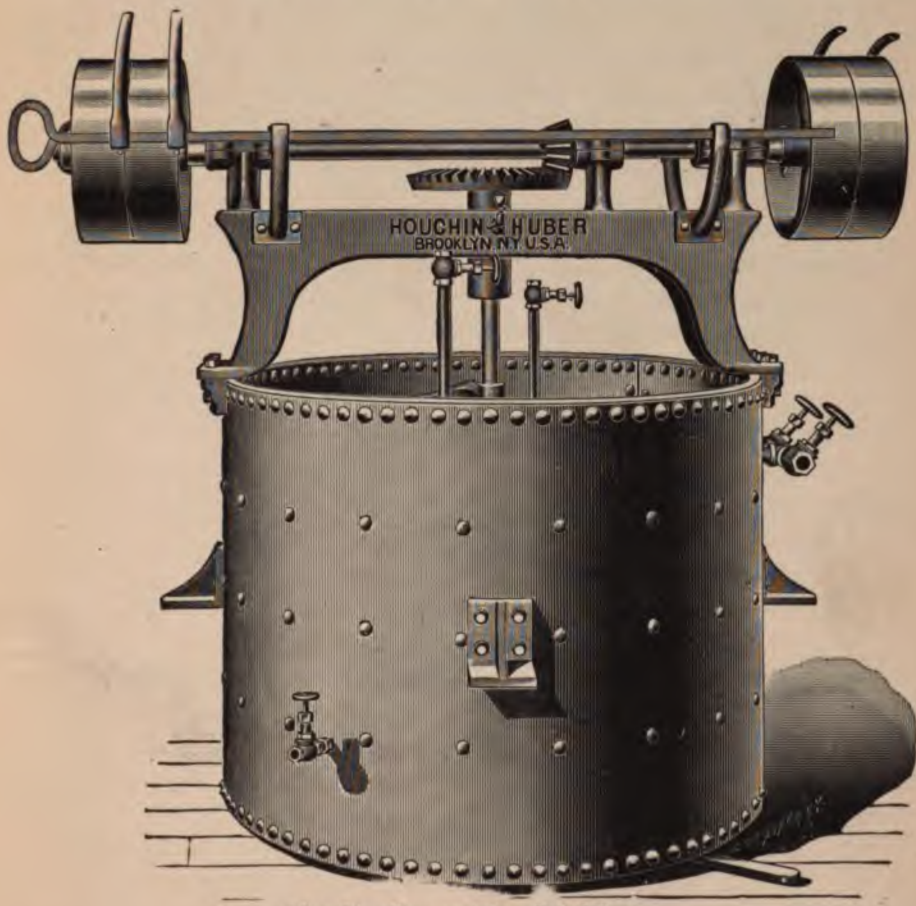


FIG. 66.—Soap-crutcher, Belt-driven.

With crutchers of this type shown in Figs. 66 and 67, driven respectively by belt and by direct-connected engine, mixing is thus effected by means of a vertical screw enclosed in a jacketed inner cylinder, the outer cylinder and the bottom being jacketed as well. With the belt-driven crutcher reverse motion is obtained by means

of an extra pair of pulleys carrying a crossed belt. With the crutcher driven by the direct-connected engine reverse motion is effected by means of a clutch. Reversing is necessary at times with thick, heavy

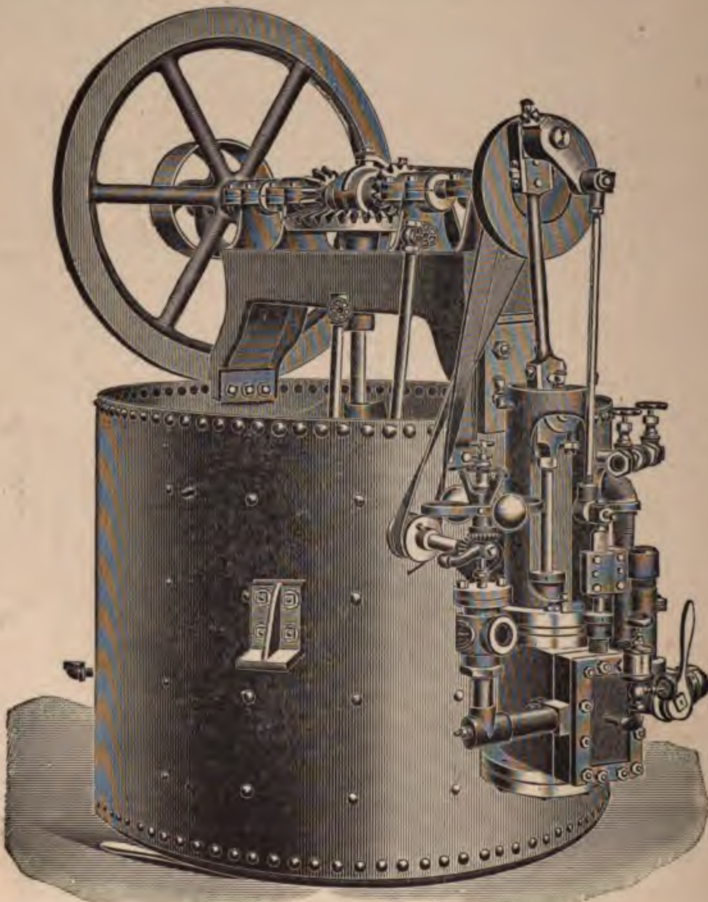


FIG. 67.—Soap-crutcher, Driven by Direct-connected Engine.

soap, and also to prevent splashing of the contents with rapid movement of the screw when cold-process soap is made.

The Soap-frame.—A soap-frame consists essentially of a platform called the frame-bottom, upon which rests the mass of soap and four upright movable sides which, in addition to being fastened

tightly together, must also be held or fastened tightly to the platform, the whole device being on wheels for convenience in moving. The modern frame of which a type is shown in Fig. 68 is usually of wooden ends with sheet-steel sides reinforced by angle-iron or V-shaped sheet-steel strongbacks, with a capacity of 1200–1300 pounds of filled soap. The essential requirements of a soap-frame are strength,

FIG. 68.—Soap-frame.

lightness, freedom from leakage, ease and rapidity of stripping and setting up, and durability. The various styles made and used differ in construction and appliances designed to fulfil the above requirements. The most important dimension in a soap-frame is the width, for upon this depends largely the percentage of scrap soap obtained at the cutting-table. Frame ends and bottoms are of wood, and as a rule twice as many bottoms as sets of sides are required. After removing the sides and ends, the soap remains on the bottom until

slabbed and cut; with an extra bottom the sides and ends may be in use again before the original bottom is available.

Slabber and Cutting-table.—Mechanical slabbing devices contain the germ of the primitive system wherein a wire is drawn in parallel lines of uniform distances apart through the frame of soap. This system is yet followed in many factories and exists in various stages of development throughout the industry. Where a large number of brands of various sizes are cut and from the same grade of soap, a hand-slabber, Fig. 69, represents the greatest practicable economy. An advance in efficiency of operation is indicated by

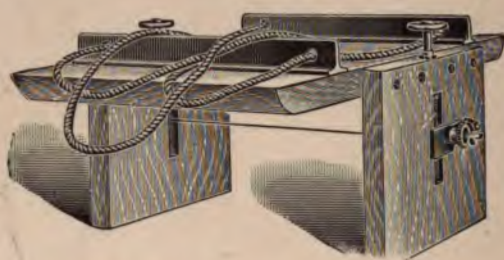


FIG. 69.—Hand Soap-slabber.

the use of slabbers of the type shown in Fig. 70. With a large volume of business the use of power-driven slabbers (of which there are several types) may be advisable.

The purpose of the cutting-table is to reduce the slab, cut as a rule to a thickness that corresponds to the width of the cake, into the maximum number of cakes with the least amount of scrap. This is effected by means of two cutting movements at right angles to each other. The general construction and operation of the cutting-table, which may be either hand- or power-driven, is shown by the illustration of a common form of table in Fig. 71. The cutting heads, which consist of a frame of wood or iron supporting the cutting wires, are removable, whereby the slab of soap may be reduced to cakes of varying dimensions, according to the distances separating the wires in the cutting heads used. In using the hand-driven cutting-table, Fig. 71, the operator places the slab upon the table and by means of the handle that operates the header forces the slab through the first cutting head. A second operator in turn

forces the slab cut lengthwise through the second cutting head and upon the racks placed ready to receive the soap thus cut into cakes. With the power-driven cutting-table the operation is continuous

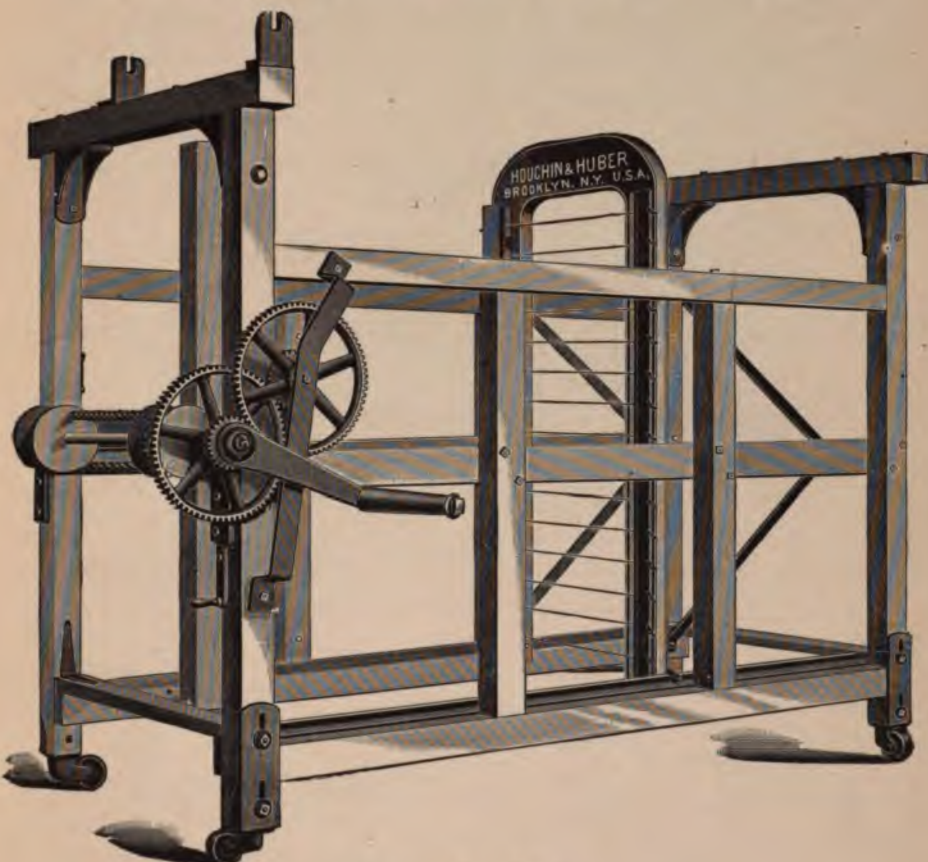


FIG. 70.—Soap-slabber.

and automatic, following the same movements hereinbefore outlined.

Drying of Soap.—Freshly cut soap is soft, sticky, and opaque, and, if properly crutched, should be homogeneous. It contains from 30 to 35 per cent. of water, depending upon the manner in which the soap was finished, and upon the nature of the addition during crutching. In calculation, 100 parts of neutral glycerides

are considered to yield 150 parts of finished soap. An analysis of a pure curd soap at this stage presents the following data: Fat anhydrides, 61.80 per cent.; combined alkali, Na_2O, 7.21 per cent.; water, 30.99 per cent.

The presence of a greater amount of water than is here shown would tend to indicate an intentional addition, its incorporation being made possible without excessive softening by the use of soda-ash and sodium silicate.

Previous to the introduction of the rapid-drying apparatus the moisture in the exterior parts of the bar was allowed to evaporate

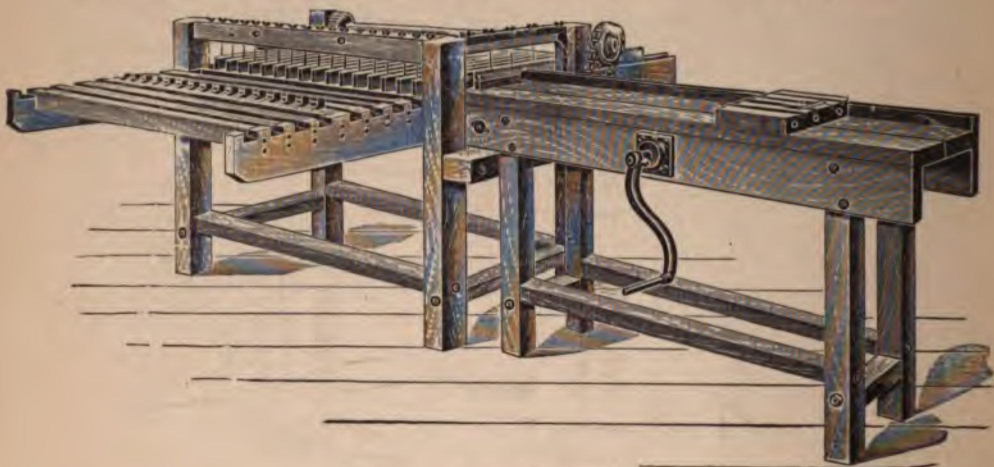


FIG. 71.—Soap-cutting Table.

spontaneously. By this method the drying was an extremely slow process, and also very unsatisfactory in that the weather was the arbiter of the output. A stove in a closed room was a great improvement. This primitive method, with its manifest disadvantages, was succeeded by a system of hot-air circulation by natural draft. Steam heat by simple radiation from pipes was also employed, and with the introduction of forced draft the elements of the system of drying at present in use were established.

The purpose of the drying-room is to hasten the evaporation of water from the surface of the bar so that there may be formed a thin crust of comparatively hard soap, which serves to retard further evaporation from the interior, and which allows the bar to

be pressed and stamped without the soap adhering to the dies. Without the formation of this skin of firm soap, the latter process is impracticable. On cutting a bar of soap into halves, this superficial drying becomes plainly evident. The soap when removed from the drying-room, and after pressing, has a smooth, glossy, and translucent surface, which condition is in marked contrast to that observed at the cutting-table. During the drying process from 3 to 5 per cent. of water has been expelled entirely from the surface of the bar, while the interior contains the amount of water originally present, viz., 30 to 35 per cent.

The appearance of soap is affected by the evaporation of water from within the mass, and by the absorption of water from without. Drying ensues at all times, but diminishes as the dew-point is approached when it reaches zero. Moisture condenses upon the surface or is absorbed at a rate increasing as the dew-point is reached, where the tendency for any soap is at its maximum. It varies with different soap according to its stock and method of manufacture. It is greatest with olein stock, of which cottonseed-oil is the chief representative, and rosin, and greater with soap made by the boiled than by the cold process. The "sweating" of soap is directly as its solubility, and is least with soap made from firm stock.

In the drying process air fulfils two functions: it carries to the moist soap the heat necessary for evaporation, and serves as a vehicle for the removal of vapor. The capacity of air for heat is very small, its specific heat being but .238, with water as 1. Its capacity for vapor depends directly upon its temperature and its relation to the dew-point, naturally diminishing as the point of saturation is reached. With rise of temperature the capacity of air for vapor greatly increases. It is estimated that air at 72° Fah. has a threefold greater capacity for vapor than the same volume at 42° Fah.; at 132° Fah. its capacity has increased 20 times, while at 172° Fah. its capacity is more than 80 times as great. Increase of temperature thus means the more rapid formation of vapor, with a much greater increase in the capacity of air for absorbing it. Add to this the rapid circulation of air, presenting to the moist surface at every instant an atmosphere greedy for moisture, and the great convenience and efficiency of artificial drying become evident. The essential requirements of

the heating and ventilating apparatus of the drying-room are that it should provide a large volume of air at the requisite temperature and maintained in rapid circulation. A comparatively low temperature, 80–100° Fah., is productive of the best results. A temperature in excess of 100° Fah., or air maintained at this temperature for any considerable period, is not only unnecessary but undesirable. At this temperature, if allowed to remain too long in the drying-room, the soap undergoes an appreciable softening with the development of more or less discoloration. The temperature at which soap will melt depends primarily upon the nature of the stock from which it is made and the proportion of water with which it is associated. In the drying of green soap it is desirable that the currents of warm air should circulate lengthwise of the bar, in order that the largest extent of evaporative surface may be exposed, and the drying process thus hastened.

Aside from the processes in the kettle, there is no stage in the manufacture of settled soap that requires greater care in its operation than the treatment received in the drying-room. Improperly dried soap, while it may cause no great trouble in the press, is subject to rapid deterioration in appearance, and the influence of this one factor on its ultimate distribution demands that its final treatment in the factory be the subject of the closest attention of the soap-maker.

Dry-room. — The mechanics of the modern soap-drying room represent more than the translation of a similar process employed in other departments of industry than it does a natural evolution from previous efforts in this particular field. The use of the centrifugal fan in the production of artificial draft dates from the sixteenth century, but it was not until Stevens' experiments in the early part of the nineteenth century that the devices for artificial draft resolved themselves into the two systems of ventilation we know to-day, viz., the plenum and vacuum, or, respectively, forced and induced draft. These found their first application in the firing of boilers. The use of centrifugal fans in this connection, however, languished at first, but with the growing demand for increased engine speed and higher steam pressure their employment as a substitute for natural draft in the combustion of fuel has become

almost universal. The application of the improved fans in the heating and ventilation of large buildings was a natural step. Considered more intimately in connection with the drying of soap, ventilating-fans may be divided into two general classes, viz., the centrifugal fan or blower and the propeller or disc fan. The former is more generally confined to ventilation by forced draft and is designed primarily for removing air under pressure. Fans of the disc type are not adapted for plenum ventilation. They find an extensive use and are very satisfactory for moving air under slight resistance.

Both systems of ventilation, the plenum and the vacuum, are employed in the drying of soap. The equipment of a drying-room under the plenum system comprises, as a rule, a centrifugal blower operated either by belt from shafting or by direct- or belt-connected engine and a sectional heater, which consists of steam-pipes enclosed in a sheet-iron case which communicates with the discharge of the fan-case. Air may either be drawn through the heater and discharged at the desired temperature into the drying-room, or the heater may be interposed and the air forced into the drying-room directly from the heater. As the results produced are the same in both cases, convenience of application will determine the arrangement. With forced draft the drying-room is so constructed that heated air enters at one end and leaves at the other, while freshly cut soap is introduced from the side, and as the drying progresses it is drawn towards the efflux of heated air and is finally removed at the opposite side. The heater and fan may be placed at opposite ends of the room and the fan employed to exhaust the warm and moisture-laden air. With this arrangement we have an example of the vacuum system, or drying by induced draft. The use of a fan of the centrifugal type is now not desirable. The cheaper and simpler disc fan set in the framework of the wall is, with this arrangement for the drying of soap, equally efficient and satisfactory. The hot-blast drying apparatus, although compact, occupies valuable space. The exhaust-steam connections with the necessary insulation are simple and easily made.

By distributing the pipes of the sectional heater throughout the drying-room in rows parallel to the trucks of soap, and under openings immediately above for the admission of cold air, not only is

greater uniformity of the drying process obtained, but the use of the cheaper disc fan, which is admirably adapted for this type of ventilation by exhaustion, is permitted. Exhaust-steam connections are made through the floor, and by means of suitably placed valves steam may be cut off from any section, thus varying the capacity of the drying-room at will. This type of drying-room equipment is in use in many of the largest soap-manufactories in this country, and certainly represents an evolution in simplicity and cheapness of the forced-draft system of ventilation as applied to the drying of soap.

Pressing Soap.—For preparing soap in the form in which it is commonly sold a press and dies are necessary. The most common form of the latter is the box die which is used universally for laundry soap. It consists essentially of a box in which the cake of dried soap is compressed by the upper and lower dies, the stationary box bolted through the lugs to the bed-plate of the press, and the movable upper and lower dies constituting the mould. The foot-press shown in Fig. 72 provides a sudden and powerful blow upon the cake of dried soap placed in the box of the die with the thumb and index or second finger of the right hand, the left hand being used in the same manner to remove the pressed cake as it is forced out of the box by the upward movement of the lower die. Power is applied by the foot of the operator, and is aided by a system of counterpoised weights which after the blow has been delivered return to their original position, at the same time expelling the pressed cake of soap from the box. By reference to Fig. 72 it is seen that a foot-press consists essentially of a bed-plate suitably grooved for the firm clamping of the die-box, a movable plunger for the elevation and depression of the lower die, and a vertical shaft moving truly in a guide and to which is attached the shank of the upper die, the whole being supported by a substantial base with legs. By suitably adjusting the counterpoised weights the power of the blow can be adapted to soap of any texture or degree of firmness. The output of a foot-press depends upon the shape and size of the cake, the condition of the soap as to dryness, and the skill of the operator. One hundred boxes of one hundred cakes to the box, if pressed well, is considered a fair day's work. Soap-pressing by manual labor is subject to many disadvantages, chief

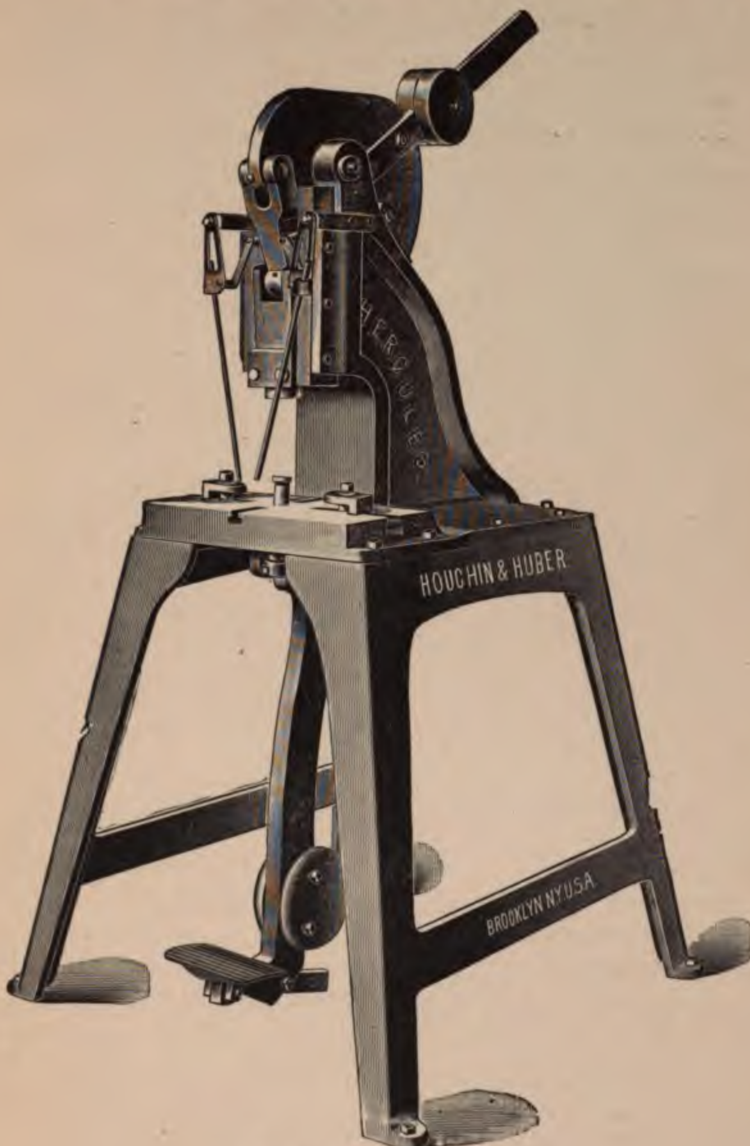


FIG. 72.—Foot Soap-press.

of which is the common liability of the operator to loss of fingers through carelessness. Automatic power-presses are now successfully used for this purpose, and with an output of sufficient volume and of uniform size are more economical. The following considerations are important in determining the choice and use of a soap-press: requirements of the factory as to amount and variety of output; ready adaptation of press to dies of different types; ease of operation; noiselessness; stability; the guide for the dies must be perfect to eliminate undue wear; and the arrangement for lifting the pressed cake from the die-box must be such as to prevent defacing the impression by too forcibly ejecting the cake against the upper die.

The Theory of Saponification.—Accurate knowledge of the chemistry of saponification dates only from 1813, at which time Chevreul determined the chemical constitution of fats and oils and the nature of the effects produced upon them by alkalis. Chevreul demonstrated that ordinary fats and oils are chemical compounds consisting of a base, glycerol, and of different acids, termed generically "fatty acids," but specifically stearic, palmitic, and oleic, forming respectively in combination with glycerol, the bodies, stearin, palmitin, and olein. In aqueous saponification, stearin, which may be taken as representative of tallow, yields 95.72 per cent. of fatty acids and 10.34 per cent. of glycerol through the absorption of 6.07 per cent. of water. These numerical relations will be plainly evident from the following equations and proportions:

$$\underset{\text{Stearin (890).}}{C_3H_5(O\cdot C_{18}H_{35}O)_3} + \underset{\text{Water (54).}}{3H_2O} = \underset{\text{Glycerol (92).}}{C_3H_5(OH)_3} + \underset{\text{Stearic acid (852).}}{3C_{18}H_{36}O_2}.$$

$$\text{Stearin (890) : glycerol (92) :: 100 : } x;$$

$x = 10.337+$per cent. glycerol yielded.

$$\text{Stearin (890) : stearic acid (852) :: 100 : } x;$$

$x = 95.72$ per cent. fatty acids yielded.

This simple arithmetic lies at the foundation of the autoclave or digester processes for the manufacture of fatty acids for candle-stock. In saponification with alkali, the latter remains in com-

bination with the fatty acids and constitutes anhydrous soap. The percentage-absorption of alkali and yields of glycerol and anhydrous soap are represented as follows:

$$\underset{\text{Stearin (890).}}{C_3H_5(O\cdot C_{18}H_{35}O)_3} + \underset{\text{Caustic soda (120).}}{3NaOH} = \underset{\text{Glycerol (92).}}{C_3H_5(OH)_3} + \underset{\text{Sodium stearate (918).}}{3C_{18}H_{35}O_2Na.}$$

Stearin (890) : Na stearate (918) :: 100 : x;

$x = 103.15$ parts Na stearate from 100 parts of stearin.

Stearin (890) : caustic soda (120) :: 100 : x;

$x = 13.49$ per cent. caustic soda required for saponification.

Stearin (890) :: glycerol (92) :: 100 : x;

$x = 10.337$ per cent. glycerol yielded.

This simple arithmetic lies at the basis of the art of soap-boiling.

Soap-manufacturing Processes.—Soaps are most simply classified according to the method of manufacture, whereby all soaps fall into two general classes, viz., cold-process and boiled soaps. The latter class is again subdivided into semi-boiled and settled soaps. The terms "cold process," "semi-boiled," and "settled" are applied not only to the method of manufacture but to the product obtained thereby. This dual classification has reference chiefly to the degree of heat employed and secondarily to the time and simplicity of apparatus required. The three processes of soap manufacture will be discussed in the order of their simplicity of operation.

A cold-process soap is one made by the thorough admixture of the various ingredients at a temperature but little above the melting-point of the soap-stock. A semi-boiled soap is one that in the process of manufacture has not been grained. It differs essentially from a cold-process soap in the greater assurance of thoroughness of saponification made possible by the use of steam. A settled soap is one that has been grained, the term "settle" referring to a final condition wherein the contents of the kettle are left in such a state that the impurities will settle out. As will be observed

in these definitions the idea of purification is paramount, and aside from the suitability of any one process for soaps of special character, the processes are arranged in the order of the quality of the stock that is available for the most satisfactory results with each. As in the manufacture of cold-process soap the finished product contains all the materials added, it is very essential for the most satisfactory results that the stock used be of the highest quality commensurate with the selling-price of the product. In the semi-boiled process, there may be a partial purification in the settling-out of the nigre. Stock may be used for soap of this class that is not available for cold-process soap. In the manufacture of settled soap every lye withdrawn after graining represents a purifying process in the progress of a boil of soap; hence there is available for soap of this class, stock that could not be used in the manufacture of cold-process or semi-boiled soaps. In the following table the most common soaps are classified according to the customary method of manufacture.

Cold Process.	Boiled Process.	
	Semi-boiled.	Grained or Settled Process.
Cheap toilet-soaps Cheap toilet-soap base Laundry-soap chips *Laundry soap*	Soft soap Soap-powder base Cheap toilet-soap *Laundry soap* *Scouring-soap base* *Textile soap*	Laundry soap Toilet-soap base Soap-powder base Scouring-soap base Floating soap "Boiled-down" soap Textile soap Shaving-soap

Characteristics of Cottonseed-oil as Raw Material for Soap Manufacture.—Refined cottonseed-oil absorbs from 14.24 per cent. to 14.67 per cent. of 74° caustic soda. It liberates on saponification about 10 per cent. of glycerol. The glyceride olein, which is the characteristic ingredient of cottonseed-oil, liberates 10.4 per cent. of glycerol. Cottonseed-oil saponifies best with weak lye, not exceeding 15° Bé., and then only after long boiling. It may be facilitated by mixing it with more easily saponifiable stock as tallow.

When treated alone, lyes exceeding 15° Bé. will not combine until with the addition of water of condensation from steam the density of the lye is reduced to the requisite strength. When mixed with tallow the usual procedure is to saponify or "kill" the tallow first, leaving an excess of lye, and then add the oil. The weak lye and the presence of killed stock facilitates combination and permits the use of stronger lye than would be practicable when killed alone. A firm, settled soap from cottonseed-oil alone is not practicable. Soap made from liquid fats, or oils, i.e., from commercial glycerides of which olein is characteristic, do not make a finished soap of hard body such as can be obtained from stearin-containing fats like tallow; hence the most practical procedure for utilizing cottonseed-oil in soap manufacture is in admixture with tallow or grease. The most satisfactory proportions are determined by the character of the soap desired and to the degree to which it is desired to add rosin. The influence of rosin in a soap is to lessen the cost, reduce the firmness, darken the color, and to increase the detergency, i.e., the solubility. The influence of cottonseed-oil is likewise to reduce the firmness and to increase the solubility of a tallow soap. Hence to produce a good, marketable grade of rosin soap, the more cottonseed-oil is used the less is it desirable to increase the proportion of rosin. With a glyceride base made up of 85 parts tallow and 15 parts of cottonseed-oil, good results may be obtained for a cheap soap with the rosin percentage as high as 90. Beyond this with the proportion of oil used it is not advisable to go. As the proportion of oil in the glyceride base is increased the proportion of rosin to the total base should be reduced. Experience shows that the use of off summer oil in white soap, especially floating, increases the tendency to discoloration. This is very likely due to the presence of impurities imperfectly removed in refining and to their proneness to oxidation.

Cottonseed-oil is similar in its composition to olive-oil, both possessing olein as its characteristic ingredient; the properties of soap made from both oils are similar, and so far as actual detergent power is concerned, refined cottonseed-oil is an almost perfect substitute for olive-oil.

The use of cottonseed-oil in cold-process soap is not recom-

mended. From the nature of soap of this quality, saponification of the ingredients cannot be complete. The presence of free cottonseed-oil in a cold-process soap on aging manifests itself by rancidity and more or less discoloration. In the manufacture of semi-boiled soap, cottonseed-oil finds a more favorable outlet. Boiling with steam makes thorough saponification possible; also owing to the cleanliness of the oil little impurity remains in the nigre. The semi-boiled process, however, is of limited application. It is in the manufacture of "settled" soap that cottonseed-oil is chiefly used.

Settled Soap.—In the manufacture of settled soap three general methods of procedure may be outlined as follows:

I.		II.		III.	
Operation.	By-product.	Operation.	By-product	Operation.	By-product.
Killed stock Strength'd soap Settled soap Treated nigre	Stock lye Strength lye Nigre Nigre lye	Killed stock Strength'd soap Pickled soap Settled soap Treated nigre	Stock lye Strength lye Pickle lye Nigre Nigre lye	Killed stock Rosined soap Strength'd soap Settled soap Treated nigre	Stock lye Rosin lye Strength lye Nigre Nigre lye

Procedure I is a more extended form of the semi-boiled process in that the soap is grained and strengthened, thus permitting complete saponification and the separation of glycerin in the waste lye. Procedure II is employed for the manufacture of white floating soap and of all detergents of whatever quality that contain no rosin. The greater part of the soap used is made according to procedure III.

The Manufacture of Settled Rosin Soap.—The quality of tallow stock used is determined by the grade of soap desired to be made; the proportions of tallow and cottonseed-oil are determined by the relative prices of these competing materials, it being endeavored, with soap of a definite standard of quality, to maintain that standard at the lowest cost. As rosin is the characteristic ingredient of this grade of soap, the foundation of glyceride stock is selected on the basis of the percentage of rosin it will carry with the maximum brightness of color and firmness of body of the finished soap. As stated before, as the general effect of rosin is to soften and darken the soap, the quality and combined firmness of the glyceride stock

admixture should be in inverse proportion to the quantity of rosin used. W. W., or water-white, and W. G., or window-glass, are the grades of rosin commonly used. With lower grades of rosin the depth of color rapidly increases, with the result that, if used, the soap is greatly deteriorated in this respect.

Caustic-soda lye is most economically prepared from 74° commercial caustic. The preparation of caustic lye is fully described in the section devoted to that subject. For the saponification of tallow, 100 pounds of 74° caustic lye of 20° Bé. will saturate an equivalent weight of tallow; 100 pounds of caustic lye of 25° Bé. will saturate 133 pounds of tallow. The pipe leading from the caustic-lye tank is suitably connected with the water-pipe and by regulating the valves on both pipes the caustic lye may be diluted as required. It should not be used too strong in the beginning, as it will be difficult to start saponification. The various grades of tallow work best with a density of 15° Bé.; cocoanut-oil, with 20° Bé.; cottonseed-oil, and corn-oil, which is similar in its soap-making properties, with a density never above 15° Bé. A great excess of caustic lye at any time retards saponification by graining the mass, i.e., throwing the soap out of solution, under which conditions combination of stock and alkali is difficult. Lyes of proper density saponify readily because the soap is dissolved as fast as formed, the mass passing quickly from an emulsion to a clear paste.

Stock Change.—With tallow and cottonseed-oil stock, the tallow should be killed first and the cottonseed-oil afterwards. While these two materials differ greatly in their behavior toward the saponifying agent, it is a property of mixed stocks to blend their characteristics. Thus a difficultly saponifying stock, as cottonseed-oil, works more easily when mixed with one saponifying readily, as tallow. Likewise the same conditions may be arrived at by killing the more refractory stock in the presence of stock already combined. Experience shows that the latter arrangement leads to more satisfactory results. The boiling may be started by either running in all the tallow to be used and then the caustic lye at 15° Bé., boiling vigorously meanwhile, or the tallow and lye may be added simultaneously, with care that the latter is never added faster than it is absorbed and at no time in such excess as will grain the soap. After

saponification is well under way and all the tallow and the greater part of the lye have been added, vigorous boiling is not required. The density of the lye should be increased to 18° Bé., and toward the completion of the change, smaller quantities at 20° Bé. should be added until saturation is complete and alkali remains in excess. The cottonseed-oil is now added and well boiled through to absorb the excess of strength left from the tallow. Additional quantities of lye at 16° to 18° Bé. are now added as fast as absorbed and toward the end the density may be increased to 20° Bé. Boiling should be continued until the soap will absorb no more alkali. The completion of the change is indicated when a sample removed on a paddle and pressed between the fingers shows no signs of greasiness, but is dry and firm and is reduced to chips or small particles on pressure. It should fall from the paddle in clear, transparent flakes. The soap is now ready to grain. For this purpose, on the stock change, dry salt is used. The salt is shovelled into the kettle and uniformly distributed over the surface of the soap, which is well boiled through after each addition. The formation of a grain or curd depends upon the insolubility of soap in salt solution. On the first appearance of the separation of lye from soap removed on the paddle, addition of salt should cease and the soap be boiled thoroughly to secure intimate admixture of soap and brine. When the separated waste lye shows no cloudiness on cooling, the graining of the soap is complete. Steam is now turned off and the contents of the kettle are allowed to stand. In kettles of average size, the stock can be killed and the soap grained before noon, but where complete saponification is desired, and especially with the use of cottonseed-oil, boiling should be continued slowly throughout the day and the soap grained and the waste lye, called the stock lye, allowed to settle out overnight. In the morning the stock lye is drawn off from the bottom of the kettle and transferred to storage-tanks, where it is held for evaporation for the recovery of glycerin. The recovery of glycerin has come to be such an important feature of soap manufacture that every care is taken to secure the completest separation of this body. For this purpose it is recommended that caustic lye stronger than 15° to 16° Bé. should not be used on the stock change and that subsequent lyes

which contain little or no glycerin should be discarded. The stock lye is the largest in volume of all waste lyes withdrawn from a boiling of soap and contains practically all the glycerin, except what is retained mechanically by the soap. For glycerin recovery the stock lye should be neutral, i.e., contain no caustic soda in excess of 0.4 per cent. After the withdrawal of the stock lye, the soap is ready for the addition of rosin.

Rosin Change.—The grained soap has subsided in the kettle to a depth equal to the volume of waste lye withdrawn. A little steam is turned on to keep the soap hot during the addition of the rosin, which is thrown in as fast as it is broken up until the charge is complete. Caustic lye at 20° Bé. is now added and the soap boiled vigorously. Additions of lye at the same strength are made as often as the soap shows a tendency to close. Caustic lye at all times should be present in such excess as to keep the soap well grained. Boiling should be vigorous to insure sufficient heat to melt all the rosin, and to bring all portions of it in contact with the lye. The presence of uncombined rosin is indicated by its characteristic appearance. When saturation of the rosin with alkali is complete the soap will have assumed a uniform color. While caustic should be present in excess, an undue excess should be avoided. Toward the end of the change, with saturation almost complete, a tendency of the soap to close should be corrected by the use of dry salt. The soap at all times on the rosin change should be kept open; in the beginning with caustic lye and toward the end, when no addition of caustic lye is necessary for saturation, with dry salt. In this condition the coloring-matter and impurities of the rosin are most fully discharged into the waste lye.

To avoid unnecessarily long boiling on the rosin change, the rosin should be reduced to fragments not larger than a man's head. In this way the rosin is most readily melted and combined with alkali. Care should be observed that no unmelted rosin remains on the bottom of the kettle. With cone-shaped kettles rosin may collect in the bottom and be hard to saturate with alkali unless the steam-pipe runs to the bottom of the cone. Whether the waste lye from this change, called the rosin lye, is withdrawn neutral or with caustic soda present in greater or less amount, depends upon the practice

prevailing in any particular factory. The rosin lye should not be large in volume; it is highly charged with coloring-matter from the rosin; contains varying amounts of glycerin, often insufficient to warrant expense of evaporation; and according to conditions, it may be economy to withdraw the lye as neutral as possible and run it into the sewer. With kettles of average size, it is practicable to complete the change in one day, adding the rosin in the forenoon and boiling with caustic lye in the afternoon. When the contents of the kettle have become homogeneous, boiling should be continued more slowly and until satisfied that saturation is complete. Steam is then turned off and the rosin lye allowed to settle out overnight. On the following morning it is withdrawn, either to the sewer, if neutral, or to a storage-tank, if it contains strength, to be worked as desired with fresh stock.

Strengthening Change.—While the utmost care should be taken thoroughly to saponify the stock on the stock change and to saturate the rosin on the rosin change, more or less of the ingredients escapes combination, according as it is endeavored to withdraw neutral lye for evaporation for glycerin, or lye containing strength to be reworked with fresh stock and then to be run to the glycerin plant. The purpose of the strengthening change is to complete the work of the previous changes. Without skill and experience, it is difficult to thoroughly kill stock and leave no free alkali in the waste lye. The procedure on the strengthening change varies with different soap-boilers.

After withdrawing the rosin lye, steam is turned on and caustic lye at 15° to 20° Bé., according to the closeness of the grain of the soap, is added. Additions are made from time to time as the caustic is absorbed. When the soap tends to thicken and regular boiling becomes difficult, brine, from 12° to 20° Bé., according to the consistency of the soap, is added. Boiling is continued until the presence of caustic, as determined by the taste, does not vary.

The following procedure is also used: After the withdrawal of the rosin lye, water is added slowly with continued boiling until the soap is brought from the "open" or "grained" to the "closed" state. Boiling well meanwhile, caustic lye at 20° Bé. is added until the soap is brought back to the open state. Boiling is continued

gently, with additions of alkali as fast as it is absorbed and always in sufficient amount to keep the soap in a thin, broad grain. In organic chemical reactions it is often difficult to effect combination of last portions of reacting bodies, and especially so when handled in large volume. When soap is thrown completely out of solution, as is done when grained hard and round, this final combination is more difficult than when partly in solution but yet open enough to separate lye, as just described. The soap should be kept in this state and well boiled. Toward the end of the change the soap may be more sharply grained by the addition of brine of 25° Bé. A good separation of excess strength and coloring-matter is thus effected. Steam is turned off and the soap allowed to stand over-night. On the following morning the strengthening lye is with-drawn to storage-tanks or transferred to other kettles to be reworked with fresh stock for the recovery of the free alkali.

Finishing Change.—After withdrawing the strengthening lye, steam is turned on and water carefully added and well boiled through after each addition. It is desired on this change to leave the soap in such a state of hydration, indicated by well-defined physical appear-ances, that on standing for a period sufficient to cool the soap to a temperature of 140° Fahr. in the summer, and 150° Fahr. in the winter, it will separate into two distinct portions, viz., soap and nigre. During this period, the length of which is determined by the quality of the soap, whether it is rosined little or much, the volume of soap, and the season, whether summer or winter, the contents of the kettle arrange themselves in the order of their specific gravities, the soap rising to the top and the impurities sub-siding. As a result of this interchange the more highly hydrated soap with the impurities is in the lower part of the kettle and the firmer soap in the upper part, both portions with a good finish being separated by a sharp line of demarcation.

On the finishing change an excess of water should be avoided, otherwise a large nigre will be formed and the yield of good soap will be small. The correct adjustment of this most important factor can be learned only by experience. With a good finish the soap should be boiled, being thinned out with water from time to time as required, until it swells up in the kettle, shows no sign of

separation, and should possess only a slight taste of alkali. Toward the end of the change, with the addition of water in proper volume, the soap should, with the use of very little steam, boil up regularly in plaques from centre to circumference of the surface. The surface of the soap should be smooth and glossy in appearance, and

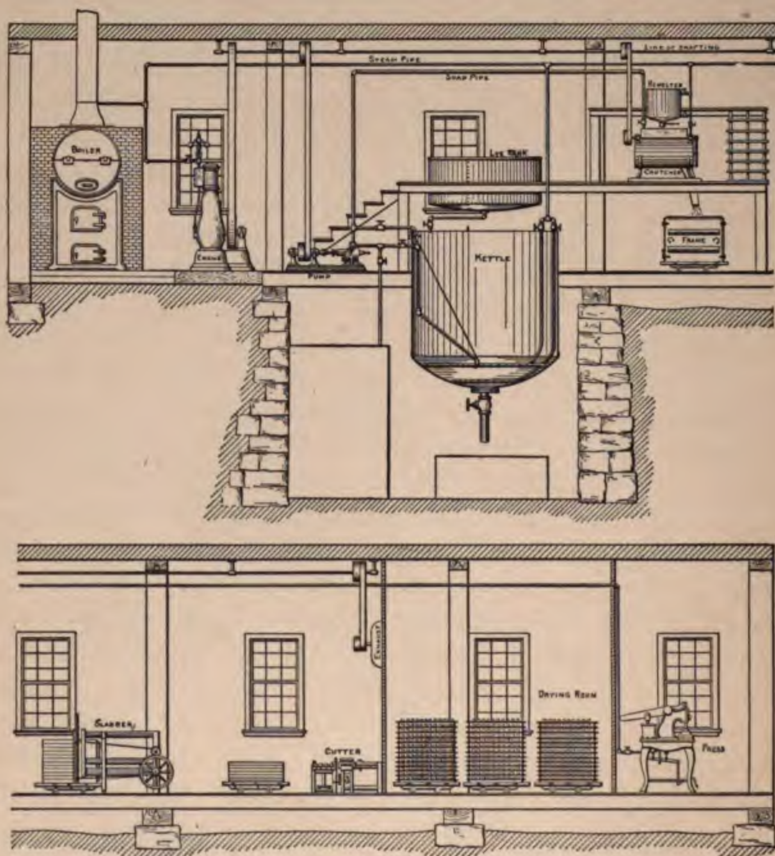


FIG. 73.—Conventional View of Soap Manufactory Showing Essential Equipment and Course (Left to Right) of Procedure.

in consistency should be firm and under no circumstance thin and flat. If the soap cannot be made to join thoroughly, i.e., if it shows signs of separation as a result of the presence of free alkali, the fault can be corrected by the addition of cocoanut-oil in requisite

amounts. When these conditions are attained steam is turned off securely and the soap allowed to cool and to separate the nigre.

The Nigre.—The proportion of the nigre to the contents of the kettle varies from 25 to 35 per cent. As the nigre is more highly hydrated than the supernatant soap, the proportion of soap in the nigre is much smaller. With uniform, careful practice it may be stated as a general rule that the proportions of anhydrous soap and water in the nigre are the reverse of what they are in the finished soap above it. The volume of the nigre is determined by the procedure followed on the finishing change. If the addition of water has been in excess, the nigre will be large. With an excess of water the soap is said to be finished "fine" or "thin." The terms "coarse" and "open" are applied to conditions at the other extreme. The more coarse or open the soap is finished the smaller will be the nigre. to the degree that no nigre will form at all and only lye separate. The intermediate condition is the one to arrive at, and, as stated above, only experience can determine it.

Crutching and Framing Soap.—By the crutching of soap is meant the thorough incorporation of various amounts of soda-ash solution at 36° Bé. and of silicate of soda solution at 40° Bé. into the hot and fluid soap. Other materials both inert and detergent may be added, the use of much of which approaches dangerously near the line of sophistication and under no circumstances is to be recommended. The crutcher or mixer is a common type of machine and consists essentially of a cylindrical tank, either plain or jacketed, containing an upright shaft supporting either horizontal arms, or a broad screw rotating within an inner concentric cylinder; both are actuated through suitable connections by belt from shafting. Another type of crutcher contains a horizontal shaft, bearing spirally inserted arms, which moves the mass from end to end, instead of from top to bottom as in the vertical type.

When the soap has cooled to a suitable temperature, viz., 140° in summer and 150° in winter, determined by removing a sample through the swing-joint pipe of the soap-kettle and testing with a thermometer, it is run preferably by means of troughs to the crutchers, best operated in pairs. As the soap in one crutcher is being crutched, the other is being filled. After the addition of a requisite

amount of soap, the filling, meaning the soda and silicate solutions, is added and crutching begun. The legitimate use of filling agents does not exceed 10 per cent. of the weight of soap. The best proportions are 75 pounds of 36° Bé. soda-ash solution and 25 pounds of silicate of soda to a single frame. After thorough mixing of this material with the soap, the whole is discharged through a door in the bottom of the crutcher into a frame on the floor below. The soap frame is essentially a box, with removable sides and ends, mounted on wheels, and of a capacity of 1200–1300 pounds of filled soap. The interior dimensions of such a frame are: Depth, 40 in.; length, 54 in.; width, 15 in. After standing at least three days, the ends and sides are removed and the soap after a lapse of a day is ready to cut into bars for drying. The subsequent manipulation of the soap consists of pressing, wrapping, and packing in boxes.

The Manufacture of Soap from Cottonseed-oil Soap-stock.—As the free fatty acids of cottonseed-oil are simply the natural glycerides of the oil with the glycerol removed, it is clear that soap made from them in the treatment of the oil on refining is equal in all of its properties to soap made from off summer yellow oil. In the former case, however, the soap is highly contaminated with the coloring matter of the seed and other organic impurities. The process by which these impurities are to a large degree eliminated has been described in the preparation of cottonseed-oil soap-stock. This material, as we have seen, consists of cottonseed-oil soap, more or less free cottonseed-oil, and the still adhering organic impurities and coloring-matter which impart to the material a persistent and characteristic odor and color. Cottonseed-oil soap-stock, in a highly purified form, may be disposed of to woollen mills to be used for the scouring of wool; but if used in the manufacture of laundry soap, it is necessary to rework it in order completely to saponify the residual free oil. Otherwise its manipulation would simply comprise its addition to the regular soap in the process of boiling for remelting and incorporation. As its influence upon a tallow soap is the same as that of cottonseed-oil transformed into an equivalent weight of soap, in all cases where the color and odor of the finished product will permit, its use is fully admissible. In the process of boiling it may be added to the tallow soap on either the stock,

rosin, or strengthening change, but preferably on the strengthening change. The strengthening change will then comprise the completion of saponification of the tallow and of the free cottonseed-oil in the soap-stock. The procedure of treatment need not differ from that already described for the strengthening change of a tallow-cottonseed-oil soap. If the soap-stock is highly colored, it may be advisable to give the soap, after the strengthening change, a pickle-wash. This is done in the following manner: After withdrawing the strengthening lye, steam is turned on and some water added to facilitate boiling. Whether sufficient water is added to just close the soap and brine of 25° Bé. used, or little or no water and brine at 12° Bé., is a matter of conditions open to choice. By the former method a sufficient quantity of saturated brine is added to give the soap a good, round grain in order to expel water with the coloring-matter in solution. After boiling to secure thorough mixing, steam is turned off and soap allowed to separate the wash-lye. The latter is then withdrawn and the boiling proceeded with as before described. Should it be desired to further improve the color of the soap, the same can be done on the finishing change, by turning off steam and allowing the soap to stand two or three hours. During this time, if the addition of water has been sufficient, a small nigre will form by the partial precipitation of the impurities. This nigre is then pumped off from below into another kettle to be reworked into a subsequent boiling. The finishing of the soap may now be proceeded with.

The Manufacture of Soap-powder.—It is in the manufacture of soap-powder that cottonseed-oil soap-stock finds its quickest and cheapest utilization as a detergent. Soap- or washing-powder is simply soda-ash and soap intimately mixed, cooled, and ground to a powder. Sodium silicate is also used as an ingredient. The soap-stock may be used with but little purification beyond subjecting it to a washing process with brine sufficient to discharge the heaviest of the organic impurities; or it may be thoroughly saponified, after having been purified to any desired degree. By the latter treatment the resulting powder is cream-colored to white; by the former, brown to yellow.

As the preparation of soap-stock from the residuum of the refi

kettle has been already described, it will only be necessary to dwell upon the treatment of the finished soap-stock. If it is desired to make a light-colored powder it will be necessary to use part off summer yellow cottonseed-oil, the proportion being determined by the degree of purification the soap-stock has undergone. With the proportions decided upon, the soap-stock should be added to the kettle and steam turned on. While the soap is melting, the cottonseed-oil may be added and lye at 15° Bé. run in. The procedure already outlined for the stock change in the manufacture of settled rosin-soap should be followed. On the completion of saponification, a slight excess of free alkali is immaterial. In preparing the finished soap for mixing with soda-ash, a little more water should be added than is used in finishing settled soap. Should the soap be finished too coarse the mixture of soap and soda-ash in the crutcher may be too thick for easy working.

Mixing and Framing.—For this purpose the soap-crutcher may be used, but it is desirable that for mixing the thick, heavy mass of soap and ash the mixer be more strongly built than the ordinary soap-crutcher and preferably of the type with either horizontal or vertical blade agitator. The ingredients added to the mixer comprise thin soap, soda-ash, and silicate of soda. These may be in various proportions according to the quality of powder desired. For a single frame 600 to 700 pounds each of soap and ash may be used to which 100 to 125 pounds of silicate are added. Soap is run in first, the amount being determined by the level in the mixer, and then the ash in successive amounts until the entire weight is added. Addition of entire amount of ash at once may block the crutcher and bend or break the blades of the mixer. The amount of silicate added will depend upon the consistency of the mixture of soap and ash. If the soap is finished too thin, the weight of ash may not be sufficient to counteract the thinness of the resulting mixture, in which event either more ash or less silicate may be added. With soap finished coarse in the kettle it may be necessary to add water in the crutcher. When a homogeneous mixture has been obtained the mass is framed. One day as a rule suffices for cooling, at the end of which time the mass is stripped and cut. Corners and ends of the frame are usually hard, and to penetrate which the ordinary

soap-slabber is unsatisfactory. Recourse is had to hand-slabbing. Should the mass become too hard to be cut by wire, it must be dis-

FIG. 74.—Disintegrator.

integrated by more laborious means. After slabbing it is cut transversely, and the slabs piled up to dry. The frame method is the most cleanly and convenient. According to the floor method, the mixed soap and soda-ash are run directly from the crutcher, used exclusively for this purpose, on to the floor of the apartment, where it is allowed to solidify, after which it is broken into coarse lumps to facilitate cooling and drying. The mass is then further disintegrated, and ground as required. The slabs after disintegration, either by hand or disintegrator, are ready for grinding. A common type of disintegrator or crusher is shown in Figs. 74 and 75.

FIG. 75.—Disintegrator with Casing.

Grinding Soap-powder.—Mills of various types are used for reducing the coarse lumps or slabs to powder, one form of which shown in Fig. 76.

A satisfactory method of handling soap-powder consists in storing the material in a hopper or bin, as it comes from the crusher, and transferring it thence by gravity to the mill as required. This arrangement of crusher, hopper for crushed material, mill and hopper for powder is shown in Fig. 77.

It will be readily seen that the arrangement shown may be varied to suit conditions, so that the crusher may be located on any floor of the building where the framed material is most easily delivered, and the mill may be also located where most convenient.

By using two small elevators, both crusher and mill may be located on the same floor, and the bins placed against the ceiling or on the

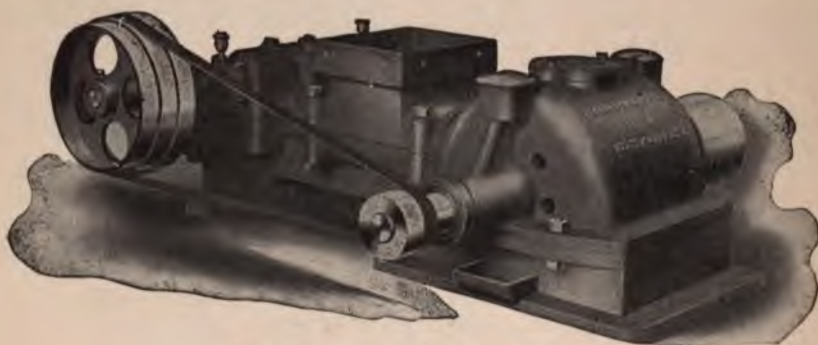


FIG. 76.—Soap-powder Grinding-mill.

floor above. In the mill shown in Fig. 76 the material is reduced to powder by repeated blows of rapidly revolving steel beaters running in a special casing. The bottom of the casing is composed of a perforated screen of a special metal, which unites great strength and toughness with phenomenal wear-resisting qualities. The powder is rapidly reduced by the action of the beaters, and the fine material is instantly discharged through the screen. All parts of the casing are easily accessible for examination and cleaning. The only wearing parts are the screens, which are durable and inexpensive. The mill is intended to receive its supply from a storage-bin overhead, and to deliver into one below or into barrels. In Fig. 78 is a diagram for setting up the mill to discharge into barrels. The frame consists of 4-in. dressed yellow pine and is large enough to take a sugar-barrel. The sides of the framework should be cov-

ered in with ordinary unbleached cotton sheeting. A door is provided, consisting of a light frame, cloth-covered, which is to be held in place by buttons as shown. The mill draws air through its sides and discharges through the screen. This air circulation is necessary to keep the powder cool.

The cloth sides of the frame allow the air to escape, while retaining the dust.

The mills can be set to discharge into a bin, elevator, conveyor, or any manner desired, but there should always be some such outlet

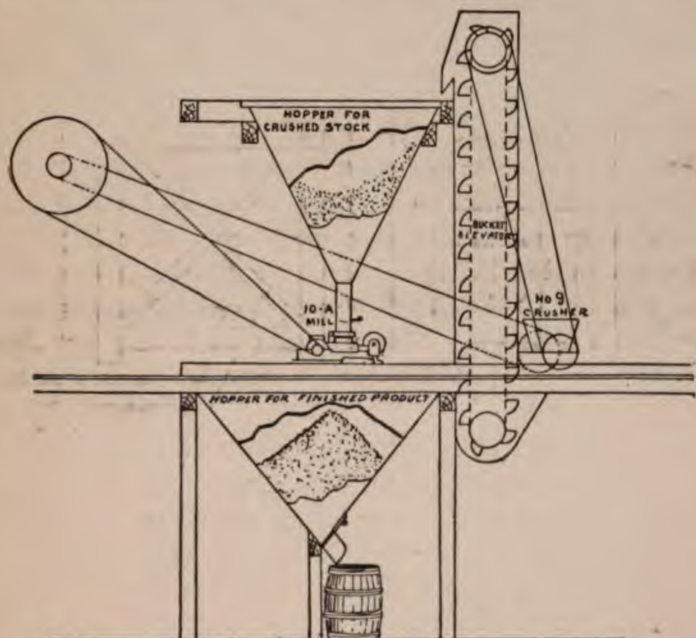


FIG. 77.—Diagram of Soap-powder Plant.

for air provided. In many cases a dust-bag, made of one piece of double-width cotton sheeting sewed together at the edges and made about 6 to 8 ft. long, will serve the purpose. The upper part can be connected by a 3-in. pipe to any convenient part of the discharge-casing, and the lower end should be hemmed and tied together with a heavy cord. When the dust accumulates, untie cord and empty out. Shake dust from sides of bag frequently. If the bag is allowed

to fill up, the air cannot escape and the machine will be liable to heat up the powder and stop work.

In Fig. 79 is shown a very compact and self-contained device for manufacturing soap-powder which is not without many points of peculiar merit. It consists essentially of a disintegrator or pulverizer which connects by means of an upright duct with a system of sieves contained in the overhead bin from which the powder, reduced to the degree of fineness required, is discharged into the

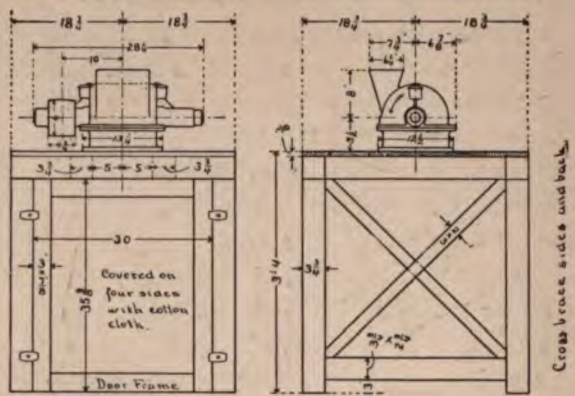


FIG. 78.—Diagram for Setting up Mill to Discharge into Barrels.

barrel on the floor, or into a bin discharging on to the floor below. The disintegrator consists of a disc bearing cast-steel pegs rotating at the rate of 1500 or more revolutions per minute and contained within a case to both sides of which likewise are attached cast-steel pegs. The disintegration of the powder is thus effected by concussion. The rapid revolution of the interior disc creates sufficient pressure to force the ground material into the sieve-chamber above, where it is deposited on a sieve of given mesh to which a lateral motion is imparted by means of a cam attached to the countershaft. The powder passes through the sieve into a suitable receptacle, while the coarser material with the air is returned by means of a tailing-duct to the disintegrator to be reground.

Packing Powder.—Where large numbers of cartons are to be packed, it is essential to adopt some method to insure that they shall all be filled exactly full and that the cost of filling shall be as low

as possible. Many of the larger manufacturers use special weighing and packing machines. The usual method is to determine the

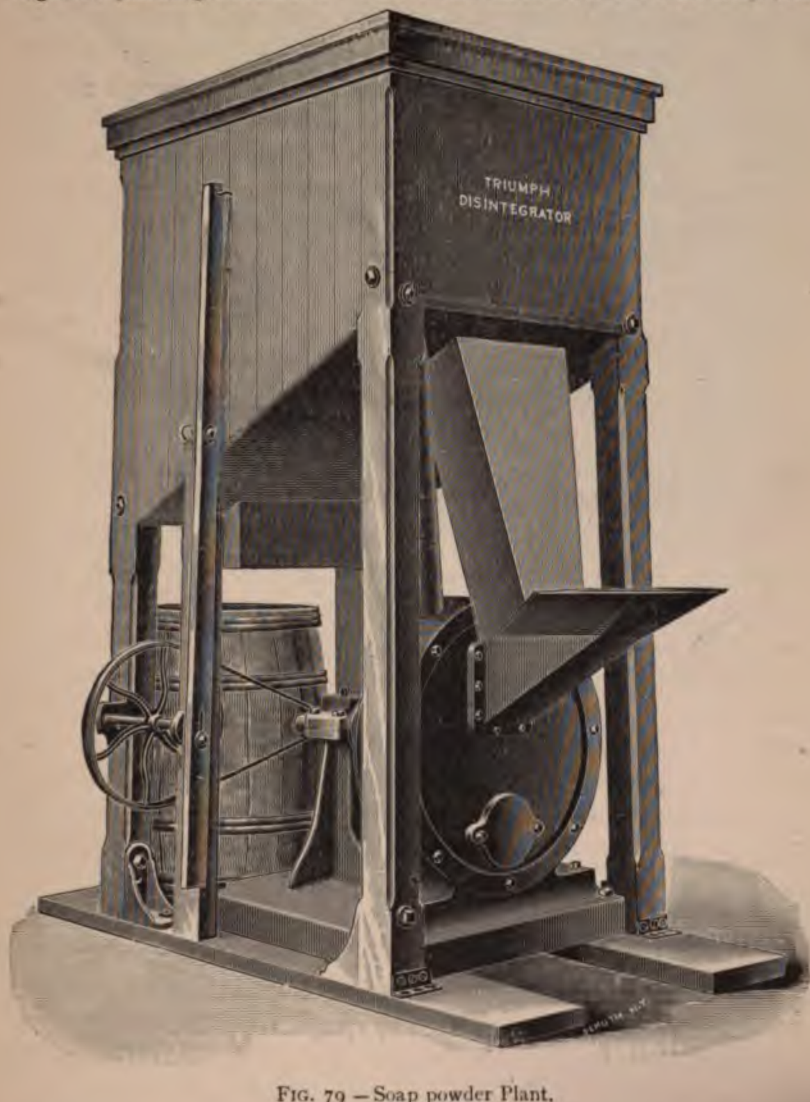


FIG. 79 — Soap powder Plant.

bulk that the desired weight of material will fill and make the ca
tons of the proper size to hold this bulk. In this connectio
should be borne in mind that there is a difference in the volum

a given weight of powder will occupy, depending on fineness of grinding. Therefore it is best to use powder just as it comes from the mill to determine this volume before ordering the cartons.

A very effective and inexpensive method of filling the cartons is to make a number of tin boxes, open on one end, of proper size to just slip inside the carton and deep enough to contain the required volume of powder. These tins are to be closely packed side by side on a tray as large as can be conveniently handled. The powder can be spread on the open top of the tins and levelled off with a shovel or hand-scoop. One minute's work will fill a whole tray of tins. The tray is then placed on the packing-table, where the packers take the tins one by one, slip a carton over the open top and turn upside down, leaving exactly the right quantity of powder in each carton, and place the empty tin on a new tray ready for refilling.

Continuous Method.—The manufacture of soap-powder on a large scale permits of the fullest opportunity for the introduction of labor- and time-saving devices. The use of an automatic weighing-machine, attached to the soap-powder bin which receives the ground powder from the mill, allows of the discharge of a uniformly regulated amount of powder into the carton or shell. From the crushing of the coarse powder by the disintegrator to the completion of the process the operation as previously described and illustrated is continuous. There is in use where the volume of manufacture permits a device or an arrangement of devices which makes the manufacture of soap-powder an uninterrupted process from the soap-kettle to the pasted package. This arrangement consists essentially of a specially constructed crutcher for mixing the ingredients, a mechanism for cooling, drying, and reducing to a coarse form the material which on a smaller scale of manufacture is framed, cooled, stripped, cut into slabs, dried and disintegrated, a grinding-mill, automatic weighing-machines, belt conveyor for filled packages, and their pasting and packing in cases by specialized labor.

CHAPTER XI.

COTTONSEED-MEAL AND COTTONSEED-HULLS FOR CATTLE-FOOD AND FERTILIZER.

Comparative Value of Cottonseed and Corn. Cottonseed-meal. Cottonseed-hulls. Comparative Value of Cottonseed-meal and Seed. Value of Seed and Meal for Feed. Cottonseed Products for Hogs and Calves. Toxic Principles. Cottonseed Products for Milk. Rations for Beef. Rations for Milk and Butter. Comparison of Concentrated Feeds. Cottonseed and Meal as Fertilizers. Value of Cottonseed on the Farm. Some Fertilizer History.

Comparative Value of Cottonseed and Corn.—The value of cottonseed for feeding purposes is not so fully understood and appreciated as the feeding value of its products, meal and hulls. They are not so readily eaten as their products are, especially meal. They are known, however, to be a valuable feeding-stuff. Experiments demonstrate that in feeding value they are fully equivalent to that of corn. From experiments made at the Texas Agricultural Experiment Station, 1 pound of cottonseed-meal was found to be equal in feeding value, i.e., beef-producing value, to 1.21 pounds of corn. Similar experiments at the Mississippi Agricultural Experiment Station demonstrated that 1 pound of cottonseed was equal to 1.06 pounds of corn- and cob-meal. The average of these two results indicates that 1 pound of cottonseed equals 1 to 1.13 pounds of corn-meal.* This means that 1 ton of cottonseed is worth as much for producing growth in beef cattle as 1.13 tons of corn or corn-meal, and that when corn is worth 40 cents per bushel ($14. per ton) cottonseed are worth $16.00, or 24.2 cents per bush 30 pounds. And with corn at 80 cents per bushel, cottonse worth as feed $32.00 per ton, or 48.4 cents per bushel.

* Com. of Agr., North Carolina, 1903.

The comparative amounts of proximate constituents in cottonseed and corn-meal are shown by the following analyses:

	Cottonseed.	Corn-meal.
Water	9.92 per cent.	15.0 per cent.
Ash	4.74 "	1.4 "
Protein	19.38 "	8.2 "
Fibre	22.57 "	1.9 "
Carbohydrates	23.94 "	68.7 "
Fat	19.45 "	3.8 "

Cottonseed-meal.—The superior value of cottonseed-meal as feed for cattle and sheep is shown by the fact that more than one-half of the output of meal is exported to foreign countries for this purpose. The remainder is divided between local consumption for feed and fertilizer and Northern consumption for dairying and feeding. As a concentrated feed it has no equal for beef cattle and dairy cows. When compared with corn and corn-meal in feeding experiments with milch-cows, it is shown to produce more milk and butter than equivalent weights of corn or corn-meal, and than generally greater weights of wheat bran and linseed-meal. This comparison likewise holds in its value for fattening beef cattle. Feeding experiments with beef cattle conducted at experiment stations in Texas, Mississippi, and Pennsylvania show that 1 pound of cottonseed-meal produced in the same rations as much beef as 1.34 to 2 pounds of corn-meal, the average being 1 pound of cottonseed-meal to 1.73 pounds of corn-meal.

Cottonseed-meal is a very rich concentrated feed, which cannot be fed alone and must be fed with care and judgment in all cases. With coarse, bulky feeds like cottonseed-hulls, the grass-hays, and the corn plant, whether shredded or cut, meal makes most excellent rations. For fattening steers, three to four pounds of meal per day are given at first, and all the hulls, hay, or corn fodder that the animal will eat without waste. The quantity of meal is increased gradually to six, eight, and ten pounds per animal per day, with hulls, hay, or corn fodder, or all, as before. The best proportions of meal and hulls, as indicated by a great many experiments, are one pound of meal to three to four pounds of hulls

after the feeding is well in progress and the animals have become accustomed to the diet.

Cottonseed-hulls.—The hulls from the seed were formerly much used for fuel for running the engines at the oil-mills, and may occasionally be used for that purpose yet; but the main demand for them is for feeding beef cattle, cows, and sheep, a demand to which the supply is not equal. It is becoming the rule for cattle to be fattened for beef at or near the mills in the South during the winter on hulls and meal.

The value of a feed depends on its composition, digestibility, and palatability. The palatability of hulls is shown by the fact that animals eat them readily and with relish. The chemical analysis of hulls, and their actual digestibility (solubility in the animal juices), as determined by a number of experiments with cattle and sheep, show them to be worth from one-half to two-thirds as much as the ordinary grass-hays. In composition they are similar to the grass-hays, but only one-half to two-thirds as much of them are actually used by the animal as of the hays. They make a very coarse, bulky feed; but a certain amount of bulk is necessary in feeding cattle and sheep, and hulls are extremely handy and convenient for diluting cottonseed-meal, which is too rich and concentrated for feeding alone. The price paid for hulls is governed by the cost of good hays.

Comparative Value of Cottonseed-meal and Seed.—The average of results obtained in feeding experiments conducted at the Texas and Mississippi Agricultural Experiment Stations shows that 1 pound of cottonseed-meal produced as much beef as 1.47 pounds of cottonseed. Comparative feeding values of corn, cottonseed, and cottonseed-meal obtained by experiment on beef cattle represent average results that may be expected with good feeding under good conditions. The feeding value of any stuff is comparative, and its price will fluctuate with that of the standard feed used for comparison with the price of the products into which it is converted. If 1 ton of cottonseed-meal will produce a growth equivalent to that produced by 1.47 tons of cottonseed, and cottonseed-meal is worth $25.00 per ton, cottonseed for the same purpose are worth $16.66 per ton or 25 cents per bushel.

The relation of cottonseed and cottonseed-meal from the standpoint of their value as stock feed and fertilizer, and the relation of the farmer, as producer of cottonseed and consumer of its non-oleaginous ingredients, to the cottonseed-oil miller, whose chief product is the oil, are tersely expressed by *The Southern Farm* as follows:

"One ton (2000 lbs.) cottonseed contains—

Of nitrogen	61 lbs.
Of phosphoric acid	20 "
Of potash	23 "

One ton (2000 lbs.) cottonseed-meal contains—

Of nitrogen	163 lbs.
Of phosphoric acid	65 "
Of potash	46 "

"Allowing that the farmer carries his seed to the mill and gives the oil as toll, he should carry back with him the resulting product, in meal about 750 pounds, and about 900 pounds of hulls.

"It is a common question whether this is a profitable exchange for the farmer.

. . . .

"It is an accepted fact that the oil has no value as a cattle-food.

"But undoubtedly a farmer can feed more economically in using meal and hulls than in feeding merely the raw seed.

"In exchanging the seed for the meal the farmer does not dispose of any of the valuable elements—nitrogen, potash, and phosphoric acid. The 750 pounds of meal contains within a small fraction all the nitrogen that was in the ton of seed.

"What price, then, should cottonseed command when cottonseed-meal is held at $16.00 per ton?

The 750 lbs. of meal from the ton of seed, at 75c. per 100 lbs., is	$6.00
Add 900 lbs. of hull from this ton of seed, at 15c. per 100 lbs.	1.35
Cash value of the ton of seed	$6.97

"At these relative values the mill would get the product of oil (30 or 35 gallons) to pay for the cost of grinding. At 20c. per gal-

lon this would give the mill $6.00 to $7.00 margin to cover all its expenses and profits.

"Whether this is too much for the mill is a question we cannot answer. If called upon for an opinion, we should say that it is not, from the fact that we would rather have the 750 lbs. meal and 900 lbs. hull, either for feeding or fertilizing purposes, than the original ton of seed."

Value of Seed and Meal for Feed.—The equivalent feeding values of cottonseed-meal and corn or corn-meal may be stated as follows:

One pound of cottonseed equals 1.13 pounds of corn or corn-meal;

One pound of cottonseed-meal equals 1.75 pounds of corn or corn-meal;

One pound of meal equals 1.5 pounds of seed.

From these figures, obtained in actual feeding tests, B. W. Kilgore* has calculated that:

1. When corn is worth 80 cents per bushel, or $1.42 per 100 pounds, or $28.40 per ton, cottonseed should be worth $1.60 per 100 pounds, or 48.4 cents per bushel, or $32.00 per ton.

2. When corn is worth 40 cents per bushel, cottonseed are worth 24.2 cents per bushel as feed, or $16.00 per ton.

3. When cottonseed are worth 25 cents per bushel, or $16.66 per ton, corn should be worth only 37.5 cents per bushel.

4. When cottonseed-meal is worth $25.00 per ton, or $1.25 per 100 pounds, cottonseed should be worth 84 cents per 100 pounds, or 25 cents per bushel, or $16.66 per ton.

5. When seed are worth 20 cents per bushel, or $13.32 per ton, meal should be worth $20.00 per ton.

Cottonseed Products for Hogs and Calves.—Nearly all of the carefully conducted experiments* show that neither cottonseed nor meal can be fed profitably to hogs and young calves. Not only can they not be fed profitably, but generally they are positively injurious and most frequently result in the death of the animal when persisted in. Whether death in these classes of animals is due to such mechanical causes as loose lint, large amount of

* Report of Com. of Agr., North Carolina, 1903.

hard and sharp seed-coats, or whether cottonseed products contain originally a toxic principle, or whether such is developed as the result of decomposition outside of or change within the animal body, is yet an open question, and is a nice and important one, to be solved in connection with the problem of feeding cottonseed products.

Toxic Principles of Cottonseed-meal.—The extensive use of cottonseed-meal for feeding purposes and the experience that it cannot be fed with safety to very young animals have directed attention to the occurrence in cottonseed-meal of bodies possessing toxic properties. Chemical analysis has isolated two nitrogenous bases termed cholin and betain, the latter being a product of the oxidation of the former and the less poisonous of the two. In a sample of cottonseed-cake examined in the U. S. Government laboratory the two bases were found present in the following relative proportions, viz., cholin 17.5 per cent., betain 82.5 per cent. Where toxic results have been experienced it is presumed that in the feed used, cholin has been relatively more abundant than betain.

Cottonseed Products for Milk.—Feeding and dairy experiments with cottonseed, cottonseed-meal, and corn indicate that their relative milk and butter-producing values are about the same as those stated for beef production. They do not injure the milk for drinking purposes, but when fed in too large quantities, they do affect the quality of the butter produced, giving it a higher melting-point and making it firm, which is an advantage in a warm climate, but at the same time the texture is injured, the butter being sticky and the flavor poor. When seed and meal are properly combined with hay and grain-feed, so that cottonseed products do not form over one-fourth of the grain ration, this injurious effect on the quality of the butter is not apparent. Two to three pounds of cottonseed or meal may be fed per cow per day without materially affecting the quality of the butter. Cottonseed-meal is rich in flesh-formers and milk-producers and its value as a dairy food is unquestioned and undoubted. It is especially well adapted for mixing with coarse feed, as hulls, corn-fodder, ensilage, and hays.

Rations for Beef.—The use of cottonseed products in admixture with coarse feeds for beef production is illustrated in the follow-

ing recommendations from the Report of the Commissioner of Agriculture of North Carolina for 1903. While these rations are especially for beef production, they are suited also for milk when it is not intended to be used for butter:

1. 1 lb. cottonseed-meal to 4 lbs. cottonseed-hulls. Feeding all that the cattle will eat readily. Corn-fodder or hay may replace a portion of the hulls in this ration.

2. 1 lb. cottonseed-meal to 5 lbs. corn-fodder (whole plant). Feeding all that the cattle will eat.

3. 1 lb. cottonseed-meal to 6 lbs. grass-hays. Feeding all the animals will eat.

4. 5 lbs. cottonseed.
5 lbs. grass-hay or corn-fodder.
13 lbs. cow-pea vine hay.

Rations for Milk and Butter.

5. 2 lbs. cottonseed-meal.
3 lbs. corn-meal.
3 lbs. wheat bran.
15 lbs. grass-hay, corn-fodder, or stover.
———
23 lbs.

6. 2 lbs. cottonseed-meal.
6 lbs. corn-meal.
8 lbs. grass-hay, corn-fodder, or stover.
8 lbs. cow-pea vine hay.
———
24 lbs.

7. 2 lbs. cottonseed.
2 lbs. corn-meal.
4 lbs. wheat bran.
8 lbs. grass-hays, corn-fodder, or stover.
8 lbs. cow-pea vine hay.
———
24 lbs.

Pasturage may be substituted for hays or coarse feeds in the above rations. Cottonseed are fed to best advantage in
tion with pasturage or an abundance of coarse feeds.

Rations 5, 6, and 7 will suit as well for beef, but are more expensive than rations 1, 2, 3, and 4.

Animals weighing about 1000 pounds eat 20 to 25 pounds of dry feed per day. Larger ones eat more, smaller ones less. All food beyond what is necessary to run the vital mechanism goes to the production of milk, butter, and beef. Liberal feeding within limit of the animal's health is most economical.

Comparison of Concentrated Feeds.—Mr. W. J. Booker, in *Flour and Feed*, gives the following statement, based on a report of Prof. E. N. Jenkins of the Connecticut State Experimental Station, showing the relative value of nitrogen, phosphoric acid, and potash contained in wheat bran, corn-meal, linseed-oil meal, and cottonseed-meal:

	Nitrogen.	Phosphoric Acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*
2000 pounds wheat bran contains	47.4	60.2	32.0
2000 pounds corn-meal contains	29.0	12.8	8.00
2000 pounds linseed-oil meal contains	106.0	38.8	20.2
2000 pounds cottonseed-meal contains	134.6	60.6	35.8

Taking the nitrogen at 17 cents per pound, phosphoric acid at 6 cents per pound, and potash at 4½ cents per pound (all of which are low valuations), gives the following as the manurial values:

	Per Ton of 2000 Pounds.
Wheat bran	$13.03
Corn-meal	6.04
Linseed-oil meal	21.55
Cottonseed-meal	28.04

In feeding, the animal retains from 5 to 20 per cent. of the above elements, so that, taking 20 per cent. from the above values, and taking wheat bran at $22 per ton, corn-meal at $24 per ton, linseed-oil meal at $28 per ton, and cottonseed-meal at $27 per ton, after deducting the cost of the manure, it costs to feed—

	Per Ton.
Wheat bran	$11.57
Corn-meal	19.16
Linseed-oil meal	6.45
Cottonseed-meal	4.56

It will be seen from the foregoing that cottonseed-meal contains, by a large percentage, a greater amount of nitrogen (protein) than any other food. It is, in fact, the most concentrated, cheapest, and most nutritious of foods, and in feeding, mixing it with bran, middlings, hulls, or other feeds, it produces an ideal cattle food. The tendency of the times is toward more scientific feeding, and the utilization of cottonseed-meal, with its high percentage of flesh-forming properties, makes a great advancement over the old method of feeding the whole seed.

Cottonseed and Meal as Fertilizers.—Meal is much used as a source of ammonia in commercial fertilizers in the cotton States, and the seed are used directly by farmers for fertilizer in no small quantity. A ton each of cottonseed and meal contain ammonia, phosphoric acid, and potash to the value of:

One ton (2000 lbs.) cottonseed contains—

Ammonia, 75 lbs. at 14 cents	$10.50
Phosphoric acid, 26 lbs. at 4 cents	1.04
Potash, 24 lbs. at 5 cents.	1.20
Fertilizing value of a ton of cottonseed.	$12.74

One ton (2000 lbs.) cottonseed-meal contains—

Ammonia, 170 lbs. at 14 cents	$23.80
Phosphoric acid, 56 lbs. at 4 cents.	2.24
Potash, 36 lbs. at 5 cents.	1.80
Fertilizing value one ton cottonseed-meal.	$27.84

It takes 2.6 tons of seed to make a ton of meal. The above figures expressing the fertilizer value of cottonseed and meal are on basis of prices of recent date * for raw or unmixed fertilizer materials in retail lots for five tons or less, for cash, at the factory. According to these valuations, when kainit delivered on the farm costs $12.50 per ton, 13 per cent. acid phosphate $11.20, nitrate of soda $50.00 per ton, and dried blood $45.00 per ton, cottonseed are worth as a fertilizer $12.74, or slightly more than 19 cents per bushel of thirty pounds.

* Report of Com. of Agr. North Carolina, 1903.

Value of Cottonseed on the Farm.—The foregoing figures were stated to be on basis of prices of fertilizer materials at the factory. The farmer would have to pay freight, merchants' commission, and cost of hauling to the farm, if he sold his seed and bought an equivalent amount of fertilizer materials to replace them. The price of seed should, therefore, be increased to meet this additional cost, and would be something like the following:

When 13 per cent. acid phosphate delivered on the farm costs $14.00 per ton, kainit with 12.50 per cent. potash costs $14.00 per ton, and nitrate of soda $60.00, dried blood of 16 per cent. $50.00, and fish-scrap $32.00, then cottonseed are worth on the farm $14.64, as follows:

One ton seed contains—

Ammonia, 75 lbs. at 16 cents	$12.00
Phosphoric acid, 26 lbs. at 5.4 cents	1.30
Potash, 24 lbs. at 5.6 cents	1.34
Fertilizing value of one ton seed	$14.64

This is equal to 22 cents per bushel of thirty pounds.

Or, in case it is desired to buy acid phosphate and kainit or some other potash salt to use with the cottonseed to make a complete fertilizer for cotton, corn, or other crops, the seed will have a still higher value, as the same amounts of ammonia, phosphoric acid, and potash always cost more in a mixed fertilizer than in the unmixed materials. Looking at the value of seed as fertilizer from this standpoint, when a mixed fertilizer, containing 8 per cent. available phosphoric acid, 2 per cent. of potash, and 2 per cent. of ammonia, costs delivered on the farm $18.00 per ton, cottonseed are worth $16.34 per ton, as follows:

One ton seed contains—

Ammonia, 75 lbs. at 18 cents	$13.50
Phosphoric acid, 26 lbs. at 5.2 cents	1.35
Potash, 24 lbs. at 6.2 cents	1.49
Fertilizing value of one ton seed	$16.34

This is equal to 24.5 cents per bushel.

Should the 8-2-2 fertilizer cost $20.00 per ton, then the seed would be worth $17.16 per ton, as follows:

One ton seed contains—

Ammonia, 75 lbs. at 20 cents	$15.00
Phosphoric acid, 26 lbs. at 5.8 cents	1.51
Potash, 24 lbs. at 6.9 cents	1.65
Fertilizing value of one ton seed	$17.16

This is equal to 25.8 cents per bushel.

The value of cottonseed as fertilizer has been presented along with the cost of ordinary fertilizer materials and a complete fertilizer, because the seed, if sold from the farm, would have to be replaced, to a considerable extent at least, by these materials for the farmer to use in mixing, or else by a complete fertilizer. This is, perhaps, the best way to convey an idea of what it will require to replace the seed, if disposed of, and every farmer should calculate what it will cost to bring back to the farm fertilizer material of equal value to the seed before deciding on the price at which to sell them.

Some Fertilizer History.—In 1866 Col. George W. Scott of Atlanta, a manufacturer of commercial fertilizers, decided to use cottonseed-meal as a substitute for other ammoniates in use at that time. He knew that in England rapeseed-meal had given good results in similar use, and concluded to try cottonseed-meal in his goods. He ordered from New Orleans a lot of the cake, which, after breaking and grinding in a corn-mill, he manipulated with dissolved bone, adding some potash and also some sulphate of ammonia, thus forming a high-grade fertilizer. Col. Scott thinks that this was the first cottonseed-meal ever used as an ammoniate for commercial fertilizers. In the fall of 1876 he established a fertilizer works at Atlanta, Ga., writing from there to Col. Nelson, who owned an oil-mill at Montgomery, Ala., asking him for a price on 300 tons of cottonseed-meal for early shipment. Col. Nelson replied, stating the price and his ability to ship, but advised Col. Scott that if he bought the quantity named he would certainly overstock himself, and suggested that the shipment had better be distributed over several months, as the oil-mills had never sold so large a quantity to

any interior dealer, the meal prior to that time going for export, as stated.

From this small beginning, of about 20 tons in 1866 and 300 tons in 1877, the use of cottonseed-meal as an ingredient in commercial fertilizers has grown to enormous proportions.

Col. Scott says: "The farmer by its use enables the millman to pay a better price for his seed and gets the safest and best high-grade fertilizer on the market when properly manipulated."

When it began to be realized that cottonseed-meal had such great fertilizing value its use as a feedstuff became relatively less important in this country. The Germans and other foreigners realized its great feeding value, and they continued to buy largely for this purpose. But about 1885 the agricultural colleges and other chemists began to devote a great deal of study and experiment to the subject of the feeding values of cottonseed-meal. A large number of bulletins were issued on this subject, also calling attention to the feeding value of cottonseed-hulls in combination with meal. The hulls had formerly been thrown away or used as fuel to operate the mills. It was shown that the feeding value of hulls per ton was as much as hay, while the fuel value was about one-third that of coal. Hence, with hay at $10 per ton and coal at $4 per ton, it was eight or ten times more sensible to feed hulls than to burn them.

The most startling discovery about the feeding of cottonseed-meal is that the systematic feeder can actually obtain full value of his cottonseed-meal as a feed and then get another full value out of it in the shape of cattle-droppings as a fertilizer. This discovery, though widely advertised by the agricultural experiment stations, is now not half appreciated by the Southern farmers. It means that while cottonseed-meal is at its present price there is 100 per cent. profit in its systematic consumption on the farm.*

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* Christopher Fitzsimmons, President Interstate Cottonseed Crushers' Association, 1904.

CHAPTER XII.

RULES FOR THE GOVERNMENT OF TRANSACTIONS IN COTTONSEED PRODUCTS.*

Cottonseed-oil. Soap-stock. Cottonseed-cake. Cottonseed-meal. Cottonseed. General Rules. Buyers' Tanks. Time Contracts. Claims. Form for Claims. Samples. Arbitration. Measurement.

Cottonseed-oil.—*Measurement.*—Rule 1. A tank (tank-car) of cottonseed-oil for contract purposes shall be 125 barrels. Tank-cars must have shell capacity in gallons at 70° Fahr. marked on each end in plain letters not less than six inches long, and seller in filling tank-car should keep record of temperature at time of filling, and exact distance between inside top of dome and surface of clear oil in tank, and in case of reclamation on account of weight buyer must show similar statement at time of receipt of tank, duly sworn to and accompanied by certificate that the car had been carefully examined before and after unloading. A barrel of oil, if sold loose, is 50 gallons. A gallon of oil is 7½ pounds avoirdupois.

2. Crude cotton-oil may be sold either loose or in barrels, as agreed between the seller and buyer. If in barrels they shall be good new iron-bound barrels, properly silicated, or thoroughly steamed and cleaned refined-petroleum barrels. Packages must be in good shipping order, and contain not less than 48 gallons each, provided that the aggregate of delivery on any sale shall equal 50 gallons for each barrel sold. On delivery of other than above barrels, an allowance of 50 cents per barrel shall be made by seller.

3. Settlements of contracts for refined cottonseed-oil shall be made on the basis of 53 gallons to the barrel. Packages for

* As amended and adopted by the Interstate Cottonseed Crushers' Association at the annual meeting at Memphis, Tenn., July 26, 27, 1899; Old Point Comfort, Va., June 14, 15, 16, 1900; New Orleans, May 14, 15, 16, 1901; Dallas, April 28, 29, and 30, 1902; Memphis, Tenn., May 26, 27, 28, 1903, and St. Louis, June 6, 7, 8, 1904.

refined oil must be good, hardwood, iron-bound barrels, new or thoroughly cleaned refined-oil barrels, painted or varnished. They must be delivered in good shipping order and shall not be under 50 or over 60 gallons each in case of delivery. On delivery of packages other than as above, an allowance not exceeding 50 cents per barrel shall be made by seller. Tares shall be tested, if required by either buyer or seller, by emptying four barrels of each 100 barrels, to be taken indiscriminately from the lot. Allowance shall be made for difference in tares in excess of one pound per barrel.

Classification.—Cottonseed-oil shall be classed and graded as follows:

4. Prime summer yellow must be clear, sweet in flavor and odor, free from water and settlings, and of no deeper color than 35 yellow and 7.1 red, on Lovibond's equivalent color scale.

"The color examination shall be made as follows: The oil is placed in a pure white four-ounce sample bottle; the depth of the oil in the bottle shall be 5¼ inches. The bottle shall be placed in a tintometer which is protected from any light except reflected white light, and the reading made at the temperature of about 70° Fahr. If the oil is of a deeper color than the glass standard, 35 yellow, 7.1 red, it shall not be prime."

5. Choice summer yellow must be sweet in flavor and odor, clear and brilliant in appearance, and free from moisture.

6. Off summer yellow shall be free from water and settlings, off in taste and color, and should be sold by sample.

7. *Prime Crude.* — Crude cottonseed-oil to pass as prime must be made from sound decorticated seed, must be sweet in flavor and odor, free from water and settlings, and must produce prime summer yellow grade by the usual refining methods with a loss in weight not exceeding 9 per cent. Provided, that any oil that refines with a greater loss than 9 per cent., but still makes prime summer yellow grade, it shall not be rejected, but shall be reduced in price by a corresponding per cent. of the contract price of the oil.

8. Choice crude oil must be made from sound decorticated seed; must be sweet in flavor and odor, free from water and settlings, and test not over 1 per cent. F. F. A.; shall produce, when properly refined, choice summer yellow oil at a loss in weight not exceeding

6 per cent. for Texas oil and 7 per cent. for oil from all other parts of the country.

9. *Off Oil.*—All oil neither choice nor prime shall be called "Off" oil, and should be sold by sample. When off oil is sold on sample any oil tendered shall be equal to sample, but if it should refine at a loss exceeding the loss of the sample by not over 2 per cent., but otherwise equal, it is still a good tender at a reduced price in proportion to the excess loss.

The buyer shall have the right to reject the oil outright if it tests beyond 2 per cent. refining loss as compared with the sale sample.

Soap-stock.—10. All sales, unless otherwise agreed upon by buyer and seller, are sold on a basis of 50 per cent. fatty acid, not to fall below 40 per cent. If containing less than 40 per cent. of fatty acid, soap-stock shall not be considered merchantable. Delivery to be made in iron-bound hardwood packages or tank-cars.

11. A contract tank-car of soap-stock shall be 50,000 pounds, unless otherwise specified.

Nothing in this rule shall be interpreted to fix the amount of draft to be drawn against shipments of soap-stock.

Cottonseed-cake.—12. A ton of cottonseed-cake is 2240 pounds, unless otherwise agreed.

13. Cottonseed-cake shall be graded and classed as follows:

Choice cake must be bright yellow in color, sweet in odor, soft and friable in texture, not burnt in cooking, free from excess of hulls, and must produce, when properly ground, a bright meal of deep-canary color.

14. Prime cake must be of good color, yellowish, not brown or reddish, sweet in odor, firm but not flinty in texture, free from excess of hulls, and must produce, when properly ground, a prime meal.

15. *Off Cake.*—All grades of cottonseed-cake which are distinctly off in color, taste, or odor, or which have been improperly manufactured so as to incorporate in them a very large percentage of lint and hulls, or to produce an exceedingly hard, flinty texture.

16. Cottonseed-cake, unless otherwise specified, shall be packed in good, strong, sound Dundee bags, either new or second-hand, at the option of the seller, unless specified in contract. Packages

must be well sewed and in good shipping order and bear a shipping-mark or a brand.

In case of shipment of carload lots or over, the official port inspector or some public weigher, after delivery to buyer, may re-weigh the shipment (but if weighed on track scales actual gross, tare, and net weights must be given), and certificates so taken, and properly sworn to, shall determine weight in all cases where cake is sold "delivered" or "weights guaranteed at destination," or, in case of loss in weight, the expense of weighing shall be paid by the seller; but in case the weights are found to be correct or under-weighed, the cost shall be paid by the buyer, and the seller shall be paid for the excess weight so determined.

Cottonseed-meal.—17. A ton of cottonseed-meal is 2000 pounds, unless otherwise stated. A sack of cottonseed-meal is 100 pounds gross weight.

Cottonseed-meal shall be classed and graded as follows:

18. *Choice.*—Must be the product from choice cottonseed-cake when finely ground, must be perfectly sound, sweet, and light-yellow color (canary), free from excess of lint and hulls. Analysis must show at least 8 per cent. of ammonia.

19. *Prime.*—Must be made from prime cake, finely ground, of sweet odor, reasonably bright in color, yellow, not brown or reddish, and free from excess of lint or hulls, and by analysis must show at least 8 per cent. ammonia for meal from Texas and the Mississippi Valley, and $7\frac{1}{2}$ per cent. for meal from the South Atlantic States.

20. *Off.*—Any cottonseed-meal which is distinctly deficient in any of the requirements of prime quality, either in color, odor, texture or analysis, or all.

When off meal is sold by sample, delivery shall equal sample in every respect except in ammonia test, and shall not be rejected if the meal delivered tests not more than one-half of one per cent. less ammonia than the ammonia test of the sample sold by, but shall be reduced by a corresponding per cent. of the contract price: otherwise it can be rejected outright.

21. Cottonseed-meal shall be packed in good sound cental or laplata bags, either new or second-hand (except where otherwise stipulated for packages designed for export in kilo or other

bags), 100 pounds gross weight, which must be well sewed and in good shipping order and bear a shipping-mark or a brand.

On shipments of carload lots or over the official port inspector or some public weigher shall have the right to open cars after delivery to buyer and take at random therefrom and reweigh a number of the bags equal to 5 per cent. of the entire number in the car, and upon the basis of weight so ascertained, and properly sworn to, the weight of the entire car shall be determined, and, in case a loss is shown, the expense of weighing shall be paid by the seller.

Should the whole or any portion of a shipment of meal or cake not turn out equal to the contract quality, the buyer shall take delivery at an allowance to be fixed by arbitration, but if any portion shall be adjudged not to be within $1.50 per long ton of the value of contract quality, the buyer shall have the option of rejecting and invoicing back such portion at market price of the quality contracted for on the day of the rejection, the market price to be decided by the arbitrators.

Cottonseed.—*Classification.*—Cottonseed shall be divided into two classes: Prime seed and Off seed.

22. *Prime Seed.*—Shall be clean, dry, sound seed, free from dirt, trash, and bolls.

23. *Off Seed.*—Seed not coming up to the requirements of prime seed shall be considered off seed. Off or damaged seed shall be settled for on its merits and comparative value as against value of standard prime seed.

General Rules.—In the event of a difference between buyer and seller as to weights, the same shall be settled by the sworn certificate of a public weigher at the point of destination. In the case of oil a certificate must be furnished showing the condition and thorough emptying of tank and connecting-pipes if weighed on tank-scales; otherwise gross, tare, and net weight shall be furnished, the expenses being divided equally.

24. All offers, sales, or purchases of cottonseed-oil (or other cottonseed products) shall be understood, unless specified to the contrary, to be f. o. b. cars at the mill, weights and quality guaranteed at destination when received in original package in good

order; loss or damage by accident or wreckage in transit to be at buyer's risk. Unless specially stated, oil shall be considered as sold loose, and buyer shall furnish tank-cars.

25. All sales of cottonseed products, unless otherwise specified, shall be for cash, payment to be made by resident buyers, on presentation of invoice with railroad ticket signed, or bill of lading attached, showing delivery of goods to the carrier in good order. Any tender of a grade of oil-meal or cake better than the grade sold shall be deemed a good delivery.

26. Payment of non-resident buyers shall be by sight or demand draft, with $\frac{1}{4}$ of 1 per cent. exchange with bill of lading attached, showing delivery of goods to the carrier in good order unless otherwise agreed.

27. When goods are delivered to the carrier as agreed, whether in whole or partial completion of trade, payment for same shall become due, if presented during banking hours; and all risks belong to the buyer.

28. On all sales of cottonseed products to or through regular brokers the seller shall pay the brokerage, unless otherwise specially agreed.

29. When a trade is closed with or through a broker it shall be understood that his fee has been earned, whether the goods are finally delivered or not.

30. On all trades by telegraph, day messages requiring day answers shall be open until 12 midnight of the day on which sent. Night messages shall be open until noon following the night on which sent. The time when telegrams are filed in telegraph-office sending same to govern, and this rule to apply only when no specific time is stated in the original offer.

31. Rules governing trades in cottonseed products are only applicable in the absence of a specific written contract stating special conditions, but either party to a trade may demand a formal written or printed contract as soon as the trade is completed. Such contracts, unless specially excepted, being subject to all the rules of this Association.

32. All trades in cottonseed products shall be either immediate, prompt, or specified dates of delivery.

(1) Immediate shall be within five working days.

(2) Prompt shall be within ten working days.

(3) Specified dates according to contract.

(4) It is understood that this rule does not refer to or in any way affect the sales of oil in buyers' tanks.

In all cases the bill of lading shall be evidence of date of shipment.

Buyers' Tanks.—33. In case the buyer furnishes tank-cars, shipments of same by buyers shall be as follows:

(1) Quick shipment of empty tank-cars shall be within two working days.

(2) Immediate shipment of empty tank-cars shall be within five working days.

(3) Prompt shipment of empty tank-cars shall be within ten working days.

(4) Specified shipments: tank-cars shall be forwarded by buyer in such time that, in the ordinary course of transportation, the tank-cars shall reach seller in time to allow him to make delivery as per contract. In case the buyer does not furnish tank-cars as specified above, the seller, on arrival of the tank-cars at his mill, at his own option, may or may not fill them, but in case he does, shall be allowed to charge the buyer $2.00 per day for each tank-car for every day's delay beyond the expiration of the contract time of shipment, but he must declare his intentions in this regard within twenty-four hours after expiration of the contract time, provided that this $2.00 per day is a demurrage charge only, and that nothing in this rule may be taken to limit or interfere with the rights of cancellation or limit the measure of damage under the contract. But in case it is shown that the tank-cars were shipped in due time as specified above, and delayed en route, the seller must fill them, charging the buyer $2.00 per day per tank as specified above, and buyer must accept them under the contract. The railroad records to govern as to time of shipments and time of deliveries of tank-cars. In case a tank-car is disabled or lost another tank-car is to be forwarded promptly by buyer to take its place, it being understood that the arrival of tank-cars at the town where mill is located shall constitute delivery as specified above.

34. If more than one tank-car is to be furnished for the same

delivery under one transaction, the first car only shall be shipped as above, and the balance shall follow as rapidly as the seller can, with certainty, load the same.

34. Par. 2. Seller shall in all cases load tank-cars within forty-eight hours of arrival at destination, and to their full capacity when within contract requirements.

34. Par. 3. In case the seller does not load tank-cars within forty-eight hours after their arrival at the mill he shall pay the buyer $2.00 per day for each tank-car for every day's delay beyond the forty-eight hours. In this case destination means mill when within free switching limits of the town where mill is located. The converse of this rule shall apply to buyers handling other tank-cars than their own.

Tank-cars delayed during settlement of dispute by arbitration or otherwise shall be subject to demurrage at the rate of $2.00 per day less the customary unloading time of forty-eight hours, the party in error to pay the demurrage.

Seller shall in all cases inspect tank-cars and clean them if necessary, at the expense of the buyer, charging only actual cost for same.

Time Contracts.—35. When a time contract is made for any one of the products of a mill, with a date specified for the expiration, and the quantity or quality or both are not stipulated, it is understood to be for all the possible output of the particular products named, that can be made from seed worked up to midnight of the last day named in the contract; the whole to be put in proper condition for shipment as speedily as possible after the date of expiration of contract.

36. In all time contracts it is understood that the mill is to run to its full capacity and to use every means known to produce goods of the quality stipulated, when so named, and if failure to do either or both of these appears intentional, then both actual and consequential damages may be awarded by the Arbitration Committee.

In case mill burns, the contract is void, provided, however, that finished products on hand at the time of the fire, covered by existing contracts and not burned or damaged, shall still apply thereon.

Claims.—37. All claims against shipments of cottonseed prod-

ucts must be made within five days after their arrival at American point of destination (except claims for demurrage on tank-cars, in which case thirty days shall be allowed in which to file claims), except a product for export, in which case twenty days shall be allowed after arrival at American point of destination.

38. No claim from any foreign market will be recognized unless the proper samples of the goods are taken and preserved previous to their leaving the American shore, unless samples are drawn before removal from foreign dock, and samples taken according to the rules governing samples. This shall only apply to shipments on through bills of lading.

39. All claims to be brought before the committee of this association must be accompanied by an affidavit from a reliable party, substantially in the following form, describing and identifying the samples submitted as taken from and fairly representing the entire shipment.

Form for Claims.—40. I, the undersigned, do hereby make affidavit that I have drawn fair and true samples from .... package of .... being not less than .... per cent. of the entire number of packages embraced in a shipment made by .... from .... as evidenced by bill of lading dated .... and issued by ....

The samples were carefully taken so as to secure a fair representation of the contents of the individual package and a true average of the quality of the entire shipment.

I certify to the correctness of the samples which are marked as follows .... and which represent the shipment marked or identified as follows: .... or contained in .... Sworn to before me, a Notary or J. P. of .... and State of ...., and duly authorized by law to take depositions, ... county and State of ...., and duly authorized by law to take depositions, this .... day of ...., 19...

Samples.—41. Samples representative of any shipment of cottonseed products, to secure the official recognition of this Association or its committees, must be secured in substantially the following manner:

42. *Oil.*—If in tank-cars at least two gallons must be taken well down in the body of oil, and from this one-gallon sample shall

be drawn and placed in a perfectly clean tin can, which shall be securely fastened up, without the use of sealing-wax, and carefully labelled so as to guarantee its identity and correctness, and for the use of the Arbitration Committee.

In case of contention and when agreed samples are not furnished, the Arbitration Committee may consider samples furnished by both the seller and buyer; careful attention being given to properly sworn statements as to the manner of procurement and identifications of the samples furnished.

43. *If in Barrels.*—A regular four-ounce sample bottle shall be filled from at least 10 per cent. of the barrels, selected at random, each sample to be from a separate barrel, and so taken as to represent its entire contents. Each sample so taken shall be sealed and labelled as provided above.

44. *Cake.*—Sample pieces not less than three inches square shall be taken from at least 5 per cent. of the packages in each car-load or in the entire lot if not shipped in car-load lots, which pieces shall be wrapped in such manner as to keep each lot separate and distinct and fairly representing the shipment from which taken. These samples shall be sealed and labelled so as to thoroughly identify them and the shipment which they represent.

45. *Meal.*—Two ounces or more from a sack shall constitute a sample of meal and must be drawn so as to fairly represent the entire contents of the bag. Twenty samples from each car-load, or fifty sacks from each 100 tons, if not shipped in car-lots, shall be sufficient to represent a shipment. Separate samples of meal should be well wrapped in heavy paper, sealed, and labelled, so as to identify them and the shipment they represent. Samples of meal, if of approximately the same grade and quality, need not be kept separate, but may be commingled, in which case they must be placed in a metal mailing- or sample-box and carefully marked, showing the number of samples taken, as well as car number and mark.

Provided, that where large lots of cake or meal are involved, representative samples taken practically as herein prescribed, not less than five pounds in weight for cottonseed-cake, or two pounds for cottonseed-meal, shall be deemed a compliance with these rules.

46. *Soap-stock.* — When in tank-cars, samples shall be drawn from flowing stock at regular intervals as tank is being loaded in the presence of the representative of the seller, as provided in Rule 47. Samples shall be taken in the approximate proportion of 2 pounds to each 10 barrels, and a thorough mixture made of the same. From this mixture three 1-pound samples shall be taken, which shall be hermetically sealed in can or Mason jar with rubber gasket. The first to be forwarded to the buyer, the second to be retained by the seller and tested by his chemist, and the third to be retained intact, hermetically sealed and properly marked for identification by the seller. If impracticable for the buyer to be represented when samples are drawn at the mill, samples shall be drawn by the buyer at destination in the presence of a representative of the seller or by a public inspector. In the event of difference in the test between the seller's chemist and the buyer's chemist, the third sample shall be submitted to a disinterested chemist to be agreed upon.

If in barrels, samples shall be drawn with a trier from each and every barrel and a gallon sample from the mixture, which shall constitute the test for the lot, samples to be drawn from tanks or barrels by sampler.

47. Par. 1. Samples shall in every case be drawn in the presence of representatives of both buyer and seller, by reliable party or parties, who shall make affidavit as prescribed by these rules in the "Form of Claims."

47. Par. 2. If the seller refuses or neglects for forty-eight hours after notification to appear in person or appoint a representative to draw the samples in the presence of the buyer or his representative for arbitration, then the buyer may appoint any disinterested person to draw such samples.

47. Samples drawn and presented to the Association, with all expenses paid in accordance with the above requirements, and with the prescribed form and agreement attached, shall be considered sufficient evidence for arbitration.

Where claims are made and not sustained, the claimant must pay all the expenses incurred.

Arbitration.—48. Par. 1. Arbitration may be held at New York, Memphis, Atlanta, New Orleans, Chicago, Dallas, or Galveston,

as agreed by the parties at difference, and, in case they cannot agree, then as determined by the Secretary of the Association. At the above-mentioned points and all others where application is made from not less than ten members, and if in his opinion it is advisable, the President of the Association, as soon as convenient after his election, shall appoint a Permanent Committee of Arbitration, to consist of five members, any three of whom shall constitute a quorum for the transaction of business. Each committee shall meet, upon call of its chairman, as often as is necessary for the prompt dispatch of business, and as compensation shall receive, for each such meeting, a fee of $35, to be divided as later provided, together with travelling and hotel expenses of the members actually in attendance and serving, which fee shall be divided equally against losers in such cases as may be acted upon at each meeting.

48. Par. 2. The party demanding the arbitration, at the time of the demand, and the other party upon consenting to it, shall deposit with the Secretary of the Association a fee of $50, of which, in case of loss, there shall be paid for each case $10 to the Association, $5 to the permanent chairman of the Committee of Arbitration, which shall be in addition to his regular proportion of the committee's fee of $35, which amount shall be divided equally between the members of the committee actually serving on the case and the expenses of each serving member, the balance, if any, to be refunded.

48. Par. 3. No personal appearance will be permitted before the Arbitration Committee except upon the unanimous request of the committee. Before calling the Arbitration Committee together the Secretary of the Association shall procure from each party to the arbitration an agreement in writing to abide by the decision of the Arbitration Committee, and to pay immediately the amount of the award.

48. Par. 4. An appeal to the Executive Committee from the decision of the Arbitration Committee may be had by either party upon written notice within five days in cases where the award is over $300. The party making the appeal shall deposit with the Secretary of the Association the full amount of the award, plus $50, to cover expenses of the appeal.

48. Par. 5. In cases of an appeal the Secretary shall call the

Executive Committee together and the majority of them shall constitute a quorum, and each member serving shall receive $10 and his travelling expenses to and from the place of meeting. The loser shall pay all expenses of the arbitration and the travelling expenses of the arbitrators.

48. Par. 6. Should a member fail or refuse to submit to the demand of another member for arbitration or delay or obstruct such demands for five days after proper notice, the chairman of the Permanent Committee on Arbitration, upon receipt of such complaint, shall proceed at once to satisfy himself as to the facts, and these being satisfactory shall immediately proceed with the arbitration ex parte, and the decision so rendered shall be of full force and effect.

48. Par. 7. Should any member refuse or delay for three days to pay in full any award of the Arbitration Committee, the other members to the arbitration may report the matter to the chairman of the Permanent Committee of Arbitration, who shall at once proceed to satisfy himself as to the correctness of the complaint, and if confirmed shall at once notify the President of the Association, who shall immediately, through the Secretary, demand of the party at fault payment, and if such payment is not made within three days thereafter, the member shall be immediately expelled from the Association, and the President, over his signature, countersigned with the Secretary's, shall so notify him and at the same time, and in the same manner, issue a circular letter to every member of the Association notifying them that such member has been expelled from the Association for not conforming with the provision of Rule 48.

Any member so expelled shall not again become a member of this Association until such claim shall have been satisfied in full, and then only upon a majority vote of the executive committee.

48. Par. 8. All expense of arbitration shall be borne by party against whom award is made.

48. Par. 9. Should any buyer or seller incorporate in any contract of purchase and sale conditions looking to the adjustment of differences that may arise under it by any other tribunals than those provided by this Association and existing under and governed by its rules, it is understood that such contract is made and accepted

entirely independent of this Association, and differences which arise under it shall not be subject for its consideration or arbitration.

49. In case of differences between members of this Association that cannot be amicably adjusted promptly, same shall be settled by arbitration upon the application of either, and the Secretary shall call such arbitration at such place as he deems best promptly upon notice of such request. Any member refusing to arbitrate for five days after such has been demanded, or failing to pay the award of an arbitration committee within three days after having been notified of it, shall be expelled from the Association by the Executive Committee upon proper complaint, and every member of the Association notified by the Secretary.

Any member with whom an arbitration is demanded shall not be allowed to resign before all matters in question are settled; the Secretary to give all notices required under this rule by registered mail.

Measurement.—50. Rule for determination of gallons from weight of oil at different temperatures:

A gallon of cottonseed-oil at 70° Fahr. weighs 7.65 pounds.

For each Fahr. degree above 70° deduct .003 pound per gallon.

(Example: Oil at 80° Fahr. ($10° \times .003$: .03) would weigh 7.62 pounds per gallon.)

For each Fahr. degree below 70° add .003 pound per gallon.

(Example: Oil at 50° Fahr. ($20° \times .003$: .06) would weigh 7.71 pounds per gallon.)

To arrive at gallons of oil in tank-car, divide the net weight of the oil by the factor obtained as above.

(Example: Net weight oil in tank, 46,000 pounds; temperature oil in tank, 50° Fahr.; 1 gallon equals 7.71 pounds; 46,000 pounds divided by 7.71 gallons equals 5966 27-100 gallons.)

Cottonseed-hulls.—51. (1) A ton of cottonseed-hulls shall be 2000 pounds.

(2) A car-load of hulls for contract purposes shall be the minimum weight fixed by the railroad tariff prevailing at point of shipment.

(3) All claims against shipments shall be as pertaining to all other cottonseed products.

Cottonseed Linters.—Cottonseed linters shall be governed in sale by special contract.